DOCUMENT RESUME

ED 380 638 CE 068 573

TITLE	Compressed Natural Gas Installation. A Video-Based Training Program for Vehicle Conversion. Instructor's Edition.
INSTITUTION	Oklahoma State Dept. of Vocational and Technical Education, Stillwater. Curriculum and Instructional Materials Center.
PUB DATE	91
NOTE	139p.
AVAILABLE FROM	Curriculum and Instructional Materials Center, Oklahoma Dept. of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, OK 74074 (instructional package, 1 teacher and 10 student editions, order no. AD2161: $50; student edition, AD3161: $2; videotape, AD7161: $50).
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Alternative Energy Sources; *Auto Mechanics; Behavioral Objectives; Classroom Techniques; *Competency Based Education; Learning Activities; Lesson Plans; Safety; Secondary Education; State Legislation; *Student Certification; Tests; *Trade and Industrial Education
IDENTIFIERS	*Compressed Gas Equipment; *Oklahoma

ABSTRACT

This instructor's guide contains the materials required to teach four competency-based course units of instruction in installing compressed natural gas (CNG) systems in motor vehicles. It is designed to accompany an instructional videotape (not included) on CNG installation. The following competencies are covered in the four instructional units: interpret the Alternative Fuels Technician Certification Act, review general safety practices, introduction to the CNG installation process, and install a CNG system. Each unit contains some or all of the following: objective sheets, suggested activities, information sheets, job sheets, transparency masters, practical tests, written tests, and written test answers. (MN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 380 638

COMPRESSED NATURAL GAS
Installation

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY

B Frazier

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

CE068573

CIMC

Instructor's Edition

Oklahoma Department of Vocational and Technical Education
1500 West Seventh Avenue
Stillwater, OK 74074-4364

91 BOSTES

AD 1161

COMPRESSED NATURAL GAS INSTALLATION

A Video-Based Training Program for Vehicle Conversion

INSTRUCTOR'S EDITION

Developed by
Curriculum and Instructional Materials Center
Oklahoma Department of Vocational and Technical Education

91-008148

AD1161

Copyright 1991
Oklahoma Department of Vocational and Technical Education
Curriculum and Instructional Materials Center

All rights reserved

Printed in the United States of America by the
Oklahoma Department of Vocational and Technical Education
Stillwater, Oklahoma 74074-4364

This publication, or parts thereof, may not be reproduced in any form by photographic, electrostatic, mechanical, or other methods, for any use including information storage and retrieval, without written permission from the publisher.

The Oklahoma Department of Vocational and Technical Education does not discriminate on the basis of race, creed, color, national origin, sex, age, veteran status, or qualified handicap.

USE OF THIS PUBLICATION

INSTRUCTIONAL UNITS

These units of instruction are designed to accompany the instructional videotape *Compressed Natural Gas Installation*, available from the CIMC. Each student *must* have a copy of the Participant's Edition and the instructional videotape. Each instructional unit includes basic components that form a unit of instruction: performance objectives, suggested activities, information sheets, supplements, job sheets, practical tests, written tests, and written test answers. Practical tests and written tests are included in the instructor edition only, and may be duplicated for classroom use or copies may be purchased in Oklahoma by calling 800-522-5810. Out-of-state instructors may order test packets by calling 800-654-4502.

All of the unit components focus on measurable and observable learning outcomes. Instructors are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Objective Sheets

Each unit of instruction is based on performance objectives. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction, and specific objectives, stating the performance necessary to meet the unit objective.

The unit objective states the overall goal of the unit. It tells what the student should be able to do and what standard will be used to determine whether the student has achieved competency. Specific objectives outline the teaching sequence of the competencies required to meet the unit objective.

Instructors can also use the objectives to plan teaching strategies and instructional methods. Instructors should prepare for each unit by deciding how each objective can best be taught.

Suggested Activities — Instructor's Edition Only

The Suggested Activities component is to assist the instructor during the preparation stage of the teaching/learning process. The activities provide suggestions for delivery, application, and evaluation during the instructional process. Teaching suggestions are included for each objective. The instructor should read the suggested activities before teaching the units to allow time to obtain supplemental materials, prepare audiovisual materials, and contact outside resource persons. Duties of the instructor will vary according to the particular unit.

Listed are suggested resources including people and print and non-print media that may be used to teach the unit. Unit references used in the development of each unit are also provided. The instructors can use suggested resources and unit references to supplement knowledge of the subject or to help students with particular interests or objectives in the area covered. Please note that suggested resources and references listed in this publication existed when this publication was written. CIMC assumes no responsibility for providing these materials and cannot ensure the availability of these materials as individual vendors, manufacturers, and publishers may discontinue these products at any time.

Information Sheets

The Information Sheets provide "must know" content that is essential for meeting the cognitive objectives. The Information Sheets serve as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. They may also be used for coordination activities and advisory committee meetings.

Students should read the Information Sheets before the information is discussed in class. Space is provided in margins for students and instructors to add notes that supplement, localize, personalize, or provide motivation for each unit.

The Information Sheets may include notes, cautions, or warnings. These should be discussed carefully and thoroughly. Notes are short verbal additions to the information or procedural outline that provide nice-to-know and decision-making information. A note may tell the student what to look for or consider at a given step, or may explain when a step may not be applicable. Notes offer guidance that may help the student understand the process and accomplish it more efficiently. Warnings are advisories that alert the student to possible danger to himself or herself or others. Cautions are advisories that alert students to possible danger to equipment or facilities.

Job Sheets

Job Sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure to complete each task or job. The Job Sheets in this training program must be studied with the instructional videotape *Compressed Natural Gas Installation*, available from the CIMC. The instructor should demonstrate the procedures outlined in each Job Sheet. Furthermore, the instructor needs to localize the procedure according to the equipment and supplies available in the local situation.

Practical Tests — Instructor's Edition Only

The Practical Tests assist the instructor in evaluating the psychomotor activities (Job Sheets). The Practical Tests provide instructors with a valid mechanism for determining a student's level of ability to perform the procedure stated on the Job Sheet and provide the instructor with a means of evaluating the final product.

Written Tests — Instructor's Edition Only

This component provides criterion-referenced evaluation of every objective listed in the unit of instruction. All performance objectives, including those in the Information Sheets and Job Sheets must be evaluated. If objectives have been added, deleted, or modified, appropriate changes should be made on the test.

The tests may be written or oral. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered.

The acceptable response on a written test, eighty-five percent (85%) in most units, may be raised or lowered to fit the topic or student ability level. The percentage applies to the overall score, not to each individual question. The final unit grade should be obtained by combining written test scores and by considering how well the student demonstrated the desired skills.

Written Test Answers — Instructor's Edition Only

This component is designed to assist the instructor in evaluating student performance on Written Tests.

VIDEOTAPE PROGRAM LOG

PROGRAM:		COUNTER READING:
1.	Introduction to CNG Installation	00:00
2.	Mount the CNG Fuel Tank	04:34
3.	Install the CNG Regulator	09:36
4.	Install the CNG Fuel Line	16:04
5.	Connect the CNG System Wiring	20:07
6.	Install the CNG Carburetor	27:09
7.	Fill the CNG Fuel Tank	32:03
8.	Test and Adjust the System	35:28

CONTENTS

UNIT 1
Interpret the Alternative Fuels Technician Certification Act 1-1

UNIT 2
Review General Safety Practices 2-1

UNIT 3
Introduction to CNG Installation 3-1

UNIT 4
Install a CNG System 4-1

FOREWORD

In Oklahoma and nationally, there is a growing interest in compressed natural gas, or "CNG," as an alternative fuel for vehicles. Installing a CNG system offers benefits to the owners of dual-fuel vehicles, to our state's economy, and to the environment. CNG has certain cost and performance benefits over gasoline. Because CNG is a clean-burning fuel, our environment can benefit from reduced pollution. In addition, Oklahoma has a large supply of natural gas.

The growing interest in alternative fuels is evidenced by the "Alternative Fuels Technician Certification Act," which was enacted by the Oklahoma legislature in 1990.

The Oklahoma Department of Vocational and Technical Education has worked closely with state experts in CNG installation to develop this training program and instructional videotape.

Participants who successfully complete this training program can take pride in knowing that they are among the best-trained professionals in the field.

Roy Peters, Jr.
State Director
Oklahoma Department of Vocational
and Technical Education

ACKNOWLEDGMENTS

I am grateful to each of the individuals identified below for their commitment of time and expertise.

Steve Copeland
Tulsa Public Schools

Steve Dwyer
State Motor Pool

Don Goodman
Oklahoma Natural Gas

Walter Hawkins
Oklahoma Natural Gas

Gary Honeysuckle
Oklahoma Natural Gas

Mike Hughes
Corken International Corp.

Buddy Langrehr
Oklahoma Natural Gas

Orville Purinton
Oklahoma Natural Gas

Jim Smart
Tom Gorman Company

Joe Tucker
Oklahoma Natural Gas

At the Oklahoma Department of Vocational and Technical Education, appreciation goes to the following persons for their contributions to the curriculum development process: Dr. Brenda Stacy, Coordinator of the Curriculum and Instructional Materials Center; Dr. Lynna Ausburn, Development Coordinator; Vikki Dearing, Coordinator of Adult Training and Development; Ivan Armstrong, State Supervisor, Trade and Industrial Education; B. F. Rowland, District Supervisor, Trade and Industrial Education; Dana Cole, A/V Production Center Coordinator; and Perry Thoele, A/V Production Specialist. I also want to thank Rose Primeaux, Supervisor of the Word Processing Center, and Margie Kirkendall, Word Processing Operator, for their work in producing the camera-ready text. The cover was designed by Kim Hale.

Thank you to everyone involved.

Craig A. Maile
Curriculum Specialist
Curriculum and Instructional Materials Center

CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with materials that are accurate and effective. Although the CIMC strives to maintain the highest standards of development and production, oversights occasionally do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected page to indicate the correction on the copy. Mail this information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, notify the CIMC of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and suggestions for improving this publication to the following address:

Curriculum and Instructional Materials Center
Oklahoma Department of Vocational and
Technical Education
1500 West Seventh Avenue
Stillwater, Oklahoma 74074-4364

WARNING

IMPROPER INSTALLATION OF A CNG SYSTEM CAN LEAD TO PERSONAL INJURY AND/OR EQUIPMENT DAMAGE. YOU MUST COMPLY WITH ALL APPLICABLE STANDARDS, MANUFACTURER'S INSTRUCTIONS AND OTHER REQUIREMENTS. THIS PUBLICATION AND THE INSTRUCTIONAL VIDEOTAPE ARE NOT SUBSTITUTES FOR COMPLETE STANDARDS OR REQUIREMENTS.

YOU SHOULD ALSO MEET THE EXPERIENCE REQUIREMENTS IN IDENTIFIED PREREQUISITE SKILL AREAS, AND ANY OTHER APPLICABLE QUALIFICATIONS, BEFORE INSTALLING A CNG SYSTEM.

OBJECTIVE SHEET

INTERPRET THE ALTERNATIVE FUELS TECHNICIAN CERTIFICATION ACT 1

INTRODUCTION

As of July 1, 1990, the "Alternative Fuels Technician Certification Act" became operative as law in Oklahoma. This Act is contained in Section 420.52 of Title 52 of the Oklahoma Statutes. Compressed natural gas (CNG) is only one of the alternative fuels covered in this law. Others include liquefied petroleum gas, liquefied natural gas, methanol, ethanol, reformulated gasoline and electricity. This unit does not cover all of the sections and provisions of the Act.

UNIT OBJECTIVE

After completing this unit, you will have a more complete understanding of the requirements of the Oklahoma "Alternative Fuels Technician Certification Act."

SPECIFIC OBJECTIVES

After completing this unit, you should be able to

1. Recognize terms used in the Alternative Fuels Technician Certification Act.
2. Identify duties of the Committee of Alternative Fuels Technician Examiners.
3. Identify examination requirements for applicants for certificates.
4. Select from a list the qualifications for receiving a certificate as an alternative fuels technician.
5. List accepted standards for the storage and handling of liquefied petroleum gases and for the installation of CNG fuel systems for vehicles.
6. State the fees charged under the Act.
7. Select from a list conditions under which a certificate or registration may be suspended or revoked.
8. Identify possible penalties for violating provisions of the Act.
9. State the frequency of inspection of conversion equipment.

SUGGESTED ACTIVITIES	INTERPRET THE ALTERNATIVE FUELS TECHNICIAN CERTIFICATION ACT 1
PREPARATION	• Supplement this unit with additional resources. • Review the unit and plan your presentation. — Estimate the amount of material that can be covered in each class session. — Identify objectives that you can supplement with other resources. — Invite guest speakers in advance. • Design transparencies and handouts to reinforce the objectives in each unit, to provide additional information, or to facilitate in-class activities.
DELIVERY	**Objective 1** • Refer to Section 3 of the Act (Section 420.52 of Title 52 of the Oklahoma Statutes). **Objective 2** • Refer to Section 4 of the Act. **Objective 3** • Refer to Section 5 of the Act. **Objective 4** • Refer to Section 6 of the Act. • Show a sample certificate, if available. **Objective 5** • Refer to Section 6 of the Act.

- Show an example of *NFPA 52* and outline its contents. Tell participants how to obtain copies from NFPA:

  NFPA 52: Compressed Natural Gas (CNG) Vehicular Fuel Systems (current edition). Contact the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

Objective 6

- Refer to Section 7 of the Act.

Objective 7

- Refer to Section 9 of the Act.

Objective 8

- Refer to Section 13 and Section 14 of the Act.

Objective 9

- Refer to Section 15 of the Act.

EVALUATION

Written Test

- Give the Written Test after presenting the unit, but not earlier than the next class session.
- Remind participants that the questions and required performance on the Written Test match the Specific Objectives stated at the beginning of the unit.
- Review individual and group performance in order to evaluate teaching methods. Adjust your approach as needed.

UNIT REFERENCES

- "Alternative Fuels Technician Certification Act" (Section 420.52 of Title 52 of the Oklahoma Statutes).

INFORMATION SHEET	INTERPRET THE ALTERNATIVE FUELS TECHNICIAN CERTIFICATION ACT 1

OBJECTIVE 1 **Recognize terms used in the Alternative Fuels Technician Certification Act.**

- **Alternative fuel** — Fuels which result in comparably lower emissions of oxides of nitrogen, volatile organic compounds, carbon monoxide, or particulates or any combination thereof and includes compressed natural gas, liquefied petroleum gas, liquefied natural gas, methanol, ethanol, reformulated gasoline and electricity
- **Alternative fuels technician** — Any person who installs, modifies, repairs or renovates equipment used in the conversion of any engines to engines fueled by alternative fuels
- **Board** — The Alternative Fuels Technician Hearing Board
- **Commission** — The Oklahoma Corporation Commission
- **Committee** — The Committee of Alternative Fuels Technician Examiners

OBJECTIVE 2 **Identify duties of the Committee of Alternative Fuels Technician Examiners.**

- Assist and advise the Commission on all matters relating to the formulation of rules and standards
- Administer the examinations of applicants for certification

OBJECTIVE 3 **Identify examination requirements for applicants for certificates.**

- Examinations will be partly or completely in writing.
- Any applicant who fails to pass the examination on the first attempt cannot take another examination for thirty (30) days.
- Any applicant who fails to pass the examination on the second attempt cannot take another examination for ninety (90) days.

OBJECTIVE 4 **Select from a list the qualifications for receiving a certificate as an alternative fuels technician.**

1. Any person who has been licensed by the Oklahoma Liquefied Petroleum Gas Board and has successfully passed the appropriate examination; or

2. Any person who has been certified by the Committee as either having successfully passed the appropriate examination or having a valid license or certificate issued by another governmental entity with licensing or certification requirements similar to those provided in the Alternative Fuels Technician Certification Act; and

3. Has paid the certification fee and otherwise complied with the provisions of the Alternative Fuels Technician Certification Act.

NOTE: The alternative fuels technician certificates are nontransferable. It is against the law for any person who is certified according to the Alternative Fuels Technician Certification Act to loan or allow the use of this certificate by any other person, unless provided for in the Act.

OBJECTIVE 5 **List accepted standards for the storage and handling of liquefied petroleum gases and for the installation of CNG fuel systems for vehicles.**

- For the storage and handling of liquefied petroleum gases — National Fire Protection Association (NFPA) Pamphlet No. 58

- For the installation of CNG fuel systems for vehicles — National Fire Protection Association (NFPA) Pamphlet No. 52

NOTE: The Commission is authorized to adopt and develop rules or specifications relating to safety in the manufacture, assembly, sale, installation and use of alternative fuel systems for vehicles. The Commission is also authorized to modify or amend such rules or specifications.

OBJECTIVE 6 **State the fees charged under the Act.**

Alternative Fuels Technician Examination — $50.00

Alternative Fuels Technician Certificate — $50.00

Alternative Fuels Technician Certificate (renewal, if made within thirty days after expiration) — $50.00

Alternative Fuels Technician Certificate (late renewal penalty) — $10.00

OBJECTIVE 7 **Select from a list conditions under which a certificate or registration may be suspended or revoked.**

1. Making a material misstatement in the application for a certificate or registration, or the renewal of a certificate or registration;
2. Loaning or illegally using a certificate;
3. Demonstrating incompetence to act as an alternative fuels technician;
4. Violating any provisions of the Alternative Fuels Technician Certification Act, or any rule or order prescribed by the Commission; or
5. Willfully failing to perform normal business obligations without justifiable cause.

NOTE: Any person whose alternative fuels technician certificate has been revoked by the Alternative Fuels Technician Hearing Board may apply for a new certificate one (1) year from the date the certificate was revoked.

OBJECTIVE 8 **Identify possible penalties for violating provisions of the Act.**

- Any person convicted of violating any provision of the Alternative Fuels Technician Certification Act shall be guilty of a misdemeanor.
- The continued violation of any provision of the Alternative Fuels Technician Certification Act during each day shall be deemed to be a separate offense.
- Upon conviction, the person shall be punished by imprisonment in the county jail not to exceed one (1) year, or by a fine of not more than one thousand dollars ($1,000.000), or both fine and imprisonment for each offense.

- Any person who has been determined by the Alternative Fuels Technician Hearing Board to have violated any provision of the Act or any rule or order issued pursuant to the provisions of the Act may be liable for a civil penalty of not more than one hundred dollars ($100.00) for each day that said violation occurs.

NOTE: Any certificate holder may elect to surrender the certificate in place of a fine. However, the holder will be forever barred from obtaining a reissuance of the certificate.

OBJECTIVE 9 **State the frequency of inspection of conversion equipment.**

The conversion equipment on vehicles fueled by alternative fuels (as defined in Section 3 of the Act) must be inspected once a year.

WRITTEN TEST	INTERPRET THE ALTERNATIVE FUELS TECHNICIAN CERTIFICATION ACT 1

NAME _____ SCORE _____

OBJECTIVE 1

Recognize terms used in the Alternative Fuels Technician Certification Act. Write the correct term in the blank above each definition.

1. _____

   Any person who installs, modifies, repairs or renovates equipment used in the conversion of any engines to engines fueled by alternative fuels

2. _____

   The Oklahoma Corporation Commission

3. _____

   Fuels which result in comparably lower emissions of oxides of nitrogen, volatile organic compounds, carbon monoxide, or particulates or any combination thereof and includes compressed natural gas, liquefied petroleum gas, liquefied natural gas, methanol, ethanol, reformulated gasoline and electricity

4. _____

   The Alternative Fuels Technician Hearing Board

5. _____

   The Committee of Alternative Fuels Technician Examiners

OBJECTIVE 2

Identify duties of the Committee of Alternative Fuels Technician Examiners. Write an "X" in the blank beside each duty.

_____1. Assist and advise the Commission on all matters relating to the formulation of rules and standards

_____2. Develop curriculum for the training of technicians for the installation and conversion of engines

_____3. Administer the examinations of applicants for certification

_____4. Issue certificates

OBJECTIVE 3 **Identify examination requirements for applicants for certificates.** Write an "X" in the blank beside each requirement.

_____1. Examinations will be partly or completely in writing.

_____2. Any applicant who fails to pass the examination on the first attempt cannot take another examination for thirty (30) days.

_____3. Any applicant who fails to pass the examination on the first attempt cannot take another examination for sixty (60) days.

_____4. Any applicant who fails to pass the examination on the second attempt cannot take another examination for ninety (90) days.

OBJECTIVE 4 **Select from a list the qualifications for receiving a certificate as an alternative fuels technician.** Write an "X" in the blank beside each qualification.

_____1. Any person having at least two years of active experience in alternative fuels technology

_____2. Any person who has been licensed by the Oklahoma Liquefied Petroleum Gas Board, has successfully passed the appropriate examination, and has paid the certification fee and otherwise complied with the provisions of the Alternative Fuels Technician Certification Act

_____3. Any person who has been certified by the Committee as either having successfully passed the appropriate examination or having a valid license or certificate issued by another governmental entity with licensing or certification requirements similar to those provided in the Alternative Fuels Technician Certification Act, and who has paid the certification fee and otherwise complied with the provisions of the Alternative Fuels Technician Certification Act

OBJECTIVE 5

List accepted standards for the storage and handling of liquefied petroleum gases and for the installation of CNG fuel systems for vehicles.

1. _____

2. _____

OBJECTIVE 6

State the fees charged under the Act.

1. Alternative Fuels Technician Examination

   _____

2. Alternative Fuels Technician Certificate

   _____

3. Alternative Fuels Technician Certificate (renewal, if made within thirty days after expiration)

   _____

4. Alternative Fuels Technician Certificate (late renewal penalty)

   _____

OBJECTIVE 7

Select from a list conditions under which a certificate or registration may be suspended or revoked. Write an "X" in the blank beside each condition.

_____1. Making a material misstatement in the application for a certificate or registration, or the renewal of a certificate or registration;

_____2. Loaning or illegally using a certificate;

_____3. Demonstrating incompetence to act as an alternative fuels technician;

_____4. Failing to have at least two (2) years of active experience in alternative fuels technology;

_____5. Violating any provisions of the Alternative Fuels Technician Certification Act, or any rule or order prescribed by the Commission; or

_____6. Willfully failing to perform normal business obligations without justifiable cause.

OBJECTIVE 8

Identify possible penalties for violating provisions of the Act.
Write the correct letter in the blank beside each numbered item.

_____1. Any person convicted of violating any provision of the Alternative Fuels Technician Certification Act shall be guilty of ___.

a. a misdemeanor
b. a felony
c. justifiable cause
d. an injunction

_____2. The continued viola[illegible]ny provision of the Alternative Fuels Technician Certification Act during each _____ shall be deemed to be a separate offense.

a. day
b. week
c. month
d. year

_____3. Upon conviction, the person shall be punished by imprisonment in the county jail not to exceed _____, or by a fine of not more than _____, or both fine and imprisonment for each offense.

a. one (1) year, five hundred dollars ($500.00)
b. one (1) year, one thousand dollars ($1,000.00)
c. one (1) year, two thousand dollars ($2,000.00)
d. two (2) years, five thousand dollars ($5,000.00)

_____4. Any person who has been determined by the Alternative Fuels Technician Hearing Board to have violated any provision of the Act or any rule or order issued pursuant to the provisions of the Act may be liable for a civil penalty of not more than _____ for each day that said violation occurs.

a. twenty-five dollars ($25.00)
b. fifty dollars ($50.00)
c. seventy-five dollars ($75.00)
d. one hundred dollars ($100.00)

OBJECTIVE 9 | **State the frequency of inspection of conversion equipment.**

WRITTEN TEST ANSWERS	INTERPRET THE ALTERNATIVE FUELS TECHNICIAN CERTIFICATION ACT 1
OBJECTIVE 1	1. Alternative fuels technician 2. Commission 3. Alternative fuel 4. Board 5. Committee
OBJECTIVE 2	1, 3
OBJECTIVE 3	1, 2, 4
OBJECTIVE 4	2, 3
OBJECTIVE 5	1. National Fire Protection Association (NFPA) Pamphlet No. 58 2. National Fire Protection Association (NFPA) Pamphlet No. 52
OBJECTIVE 6	1. $50.00 2. $50.00 3. $50.00 4. $10.00
OBJECTIVE 7	1, 2, 3, 5, 6
OBJECTIVE 8	1. a 2. a 3. b 4. d
OBJECTIVE 9	Once a year.

OBJECTIVE SHEET	**REVIEW GENERAL SAFETY PRACTICES** 2

INTRODUCTION

Installing a CNG system safely requires you to be alert to general job safety rules, as well as safe practices specifically for working with CNG. The properties of CNG make it a generally safer fuel than gasoline. However, CNG must always be handled with respect.

UNIT OBJECTIVE

After completing this unit, you should be able to apply general safety practices while installing a CNG system.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to

1. State general job safety rules.
2. Determine colors used in the safety color code.
3. Determine the correct fire extinguisher to use for various classes of fires.
4. List in order the basic steps in using a portable fire extinguisher.
5. Properly lift a heavy object. (Job Sheet 1)

REVIEW GENERAL SAFETY PRACTICES 2

PREPARATION

- Supplement this unit with additional resources.

  Publications

  — *Safety On The Job.* Available from the Oklahoma Department of Vocational and Technical Education, Resale Division, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

  — *NFPA 52: Compressed Natural Gas (CNG) Vehicular Fuel Systems* (current edition). Contact the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

  Media

  — *Fire Safety: Extinguishers.* Available as a 16mm film or on VHS from AIMS Media, 6901 Woodley Avenue, Van Nuys, California 91406-4878, or call toll-free at 1-800-367-2467. Also available on a free-loan basis to Oklahoma instructors from the Oklahoma Department of Vocational and Technical Education, Resource Center, ATTN: Instructional Media Specialist, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

  — *Safety On The Job Series: Fire Extinguishers.* Available on VHS from AIMS Media, 6901 Woodley Avenue, Van Nuys, California 91406-4878, or call toll-free at 1-800-367-2467. Also available on a free-loan basis to Oklahoma instructors from the Oklahoma Department of Vocational and Technical Education, Resource Center, ATTN: Instructional Media Specialist, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Review this unit and plan your presentation.

  — Estimate the amount of material that can be covered in each class session.

  — Identify objectives that you can supplement with other resources.

  — Invite guest speakers in advance.

- Design transparencies and handouts to reinforce the objectives in each unit, to provide additional information, or to facilitate in-class activities.

DELIVERY

Objective 1

- Relate each rule to the job of installing a CNG system, if possible. Point out situations where a specific rule could apply.
- Discuss any other rules that may apply to CNG installation.

Objective 2

- Give examples of each color code as each may be found at a job site.
- Relate good housekeeping practices and the safety color code. Discuss how poor housekeeping could affect the visibility of signs, tags and labels.

Objective 3

- Add more examples for each class of fire. Find examples relating to the installation of a CNG system.
- Refer to Supplement 1 and Supplement 2.
- Describe a fire emergency, then ask participants to identify the class of fire involved.

Objective 4

- Obtain uncharged samples of each type of extinguisher, if possible, and allow participants to handle each type.
- Plan an outdoor demonstration under the supervision of fire department personnel, for practice in using charged fire extinguishers. Plan the demonstration to fit the schedule of fire department personnel. Review the basic steps in using a portable fire extinguisher, then allow participants to extinguish a controlled fire using the appropriate extinguisher provided.

APPLICATION

Objective 5

- Introduce Job Sheet 1.

- Demonstrate proper lifting techniques using Job Sheet 1.
- Allow participants to practice proper lifting until they are ready to be evaluated on the Practical Test.

EVALUATION

Practical Test

- Explain the purpose of the Practical Test.
- Explain the rating scale.
- Complete the Practical Test for each participant.
- Reteach and retest if needed.

Written Test

- Give the Written Test after presenting the unit, but not earlier than the next class session.
- Remind participants that the questions and required performance on the Written Test match the Specific Objectives stated at the beginning of the unit.
- Review individual and group performance in order to evaluate teaching methods. Adjust your approach as needed.

UNIT REFERENCES

- *Introduction to Automotive Service.* Stillwater, Oklahoma: Oklahoma Department of Vocational and Technical Education, 1989.
- *Safety On The Job: Some Guidelines for Working Safely.* Stillwater, Oklahoma: Oklahoma Department of Vocational and Technical Education, 1989.

INFORMATION SHEET	REVIEW GENERAL SAFETY PRACTICES 2

OBJECTIVE 1

State general job safety rules.

GENERAL SAFETY

- Wear close-fitting clothing appropriate for the work.
- Keep hands and clothing away from any moving parts of tools and equipment.
- Wear appropriate personal protective equipment when required.
- Remove all jewelry before working.
- Do not carry tools or sharp objects in your pockets.
- Life heavy objects properly.

  NOTE: See Job Sheet 1.

- Know the location of fire fighting and first-aid equipment.
- Follow all OSHA, state, employer's and manufacturer's regulations and instructions.

TOOL AND EQUIPMENT SAFETY

- Use the right equipment for the job.
- Keep tools clean and in good working condition.
- Keep guards and safety devices in place on all equipment.
- Store tools and equipment in their proper storage areas when not in use.
- Remove defective tools and equipment from service.

BEST COPY AVAILABLE

- Turn off power equipment when not in use or when adjustments or attachments are needed.

CAUTION

Unplug power tools and equipment before repairing. Never leave a running tool unattended.

- Do not hold your hand behind material being drilled.

WORK AREA SAFETY

- Arrange equipment and machinery for clear, safe working areas and ease in maintenance.
- Throw away trash and waste materials properly.
- Clear floors of obstacles and spilled substances immediately.
- Keep all aisles, exits and traffic areas clear.

VEHICLE SAFETY

- Be sure that the vehicle is out of gear before starting it.
- Use a "spotter" to help you maneuver or park a vehicle in a close area.
- Do not leave a vehicle running indoors without adequate exhaust-removal equipment in place.
- Warn other workers in the area and clear workers from the engine area when starting a vehicle.
- Be careful of moving parts and parts that heat up during engine operation.
- Wear your safety belt *whenever* you ride in or drive a vehicle.

CNG SAFETY

- Follow all applicable standards and regulations.
- Make sure that adequate ventilation is in place.

- Stop the vehicle's engine when transferring CNG to or from the vehicle.
- Always handle CNG fuel tanks with respect.

  NOTE: When full, CNG fuel tanks can contain as much as three thousand pounds of pressure.
- Inspect all components to be sure that they are not damaged.
- Pick up remaining pieces or rolls of steel tubing after use.
- Disconnect the battery ground cable before doing any wiring.
- Before drilling, make sure that you will not hit the vehicle's gasoline fuel tank, fuel line or other wiring.
- Make sure that all wiring is secured out of the way of any moving parts.

OBJECTIVE 2 **Determine colors used in the safety color code.**

Federal Safety RED

- Indicates danger
- Identifies fire protection equipment and its location
- Identifies portable containers of flammable liquids
- Identifies emergency stop bars, stop buttons, and electrical stop switches on machinery

Federal Safety YELLOW

- Indicates caution and marks physical hazards

  EXAMPLE: Low beams, steps, pits
- Indicates waste containers for explosive or combustible materials

BEST COPY AVAILABLE

- Indicates equipment that should *not* be started, used or moved

  EXAMPLE: Defective equipment, equipment being serviced

- Identifies the starting point or power source for machinery

Federal Safety ORANGE

- Identifies dangerous parts of equipment that could cut, crush, shock, or otherwise injure

- Indicates safety starter buttons

Federal Safety PURPLE (or MAGENTA or BLACK ON SAFETY YELLOW)

- Indicates radiation hazards

Federal Safety BLUE

- Identifies tags that indicate equipment that should *not* be started, used or moved

  EXAMPLE: Defective equipment, equipment being serviced

Federal Safety GREEN

- Identifies safety equipment other than fire fighting equipment and its location

- Identifies first-aid equipment and its location

Federal Safety BLACK AND WHITE

- Indicates traffic flow paths

- Indicates storage areas

- Identifies housekeeping equipment and its location

OBJECTIVE 3 **Determine the correct fire extinguisher to use for various classes of fires.**

CLASS A — Ordinary combustibles, such as wood, paper, cloth

CLASS B — Flammable liquids, such as grease, gasoline, paints, oils

CLASS C — Electrical equipment, such as motors, switches, computers

CLASS D — Combustible metals, such as iron and magnesium

NOTE: See Supplement 1 and Supplement 2.

OBJECTIVE 4

List in order the basic steps in using a portable fire extinguisher.

NOTE: Always follow the operating instructions found on the label of each extinguisher at your job site. The basic steps for using an extinguisher are similar but are not the same. You should become familiar with the proper use of each type of extinguisher that you may have to use in an emergency.

1. P — PULL the pin at the top of the extinguisher that keeps the handle from being pressed. Break the plastic or thin wire inspection band.

   NOTE: Carry and operate the extinguisher in its upright position. Only obsolete soda-acid, foam, and cartridge-operated water extinguishers are designed to be turned upside down.

2. P — POINT the nozzle or outlet toward the fire.

   NOTE: Some hose assemblies are clipped to the body of the extinguisher. Release the hose assembly, then point.

3. P — PRESS the handle above the carrying handle to discharge the contents inside. Release the handle to stop the discharge at any time.

4. S — SWEEP the nozzle back and forth at the base of the flames to speed the extinguishing agent.

   CAUTION

   After the fire is out, look for smoldering hot spots or reflash of flammable liquids. Be sure the fire is out!

Used with permission of the Board of Regents, Oklahoma State University.

BEST COPY AVAILABLE

Standard Letter Symbols for Fire Extinguishers

GREEN	RED	BLUE	YELLOW
ORDINARY COMBUSTIBLES	FLAMMABLE LIQUIDS	ELECTRICAL EQUIPMENT	COMBUSTIBLE METALS

Distinctive letters, shapes, and colors mark extinguishers according to the classes of fires on which they should be used.

New Pictorial Symbols Used to Label Fire Extinguishers

Symbols with blue backgrounds indicate fire extinguisher can be used for class of fire portrayed.

Symbols with red line across a black background indicate fire extinguisher *cannot* be used for class of fire portrayed.

JOB SHEET 1	REVIEW GENERAL SAFETY PRACTICES 2

OBJECTIVE 5

Properly lift a heavy object.

INTRODUCTION

One of the most painful and most common injuries in any workplace is a back injury from using improper lifting techniques. Injuries related to improper lifting of a heavy object can include torn or strained muscles, ligaments, and joints in the neck, arms, or legs. Most of these injuries never heal completely.

The key to proper lifting is to hold your back straight while lifting with properly-positioned legs. This Job Sheet outlines the proper way to lift a heavy object.

EQUIPMENT AND MATERIALS

- Empty box to simulate a heavy object

PROCEDURE

CAUTION

Know your limits for safe lifting. Get help if needed.

1. Step up to object; place one foot beside object and one behind (Figure 1).

FIGURE 1

2. Bend the knees and get a good handhold on the object (See Figure 2).

3. Tuck in chin (Figure 2).

FIGURE 2

4. Tuck in elbows and arms, and hold load close to body (See Figure 3).

5. Keeping back straight and body weight directly over feet, push with your legs as you stand straight up (Figure 3).

FIGURE 3

6. Lift the object into carrying position, making no turning or twisting movements until lift is completed (Figure 4).

FIGURE 4

7. Using leg and back muscles, comfortably lower load by bending your knees (Figure 5).

   NOTE: Setting the load down properly is just as important as picking the load up properly.

FIGURE 5

8. When load is securely positioned, release your grip.

PRACTICAL TEST 1	REVIEW GENERAL SAFETY PRACTICES 2

JOB SHEET 1

Properly lift a heavy object.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Assumed the proper position in relationship to the object with one foot beside object and one foot behind.	____	____
2. Began the lift by grasping the load firmly and holding it close to the body while keeping knees bent and chin, elbows and arms tucked in.	____	____
3. Lifted object into carrying position by standing straight up while keeping back straight and body weight directly over feet.	____	____
4. Lowered load while keeping back straight, using back and leg muscles properly.	____	____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator Note: The "product" in this procedure is a safely-lifted object. Rate the participant on the following criteria by circling the appropriate numbers on the Performance Evaluation Key. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

EVALUATOR'S COMMENTS

_____

_____

_____

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST	REVIEW GENERAL SAFETY PRACTICES 2

NAME _____ SCORE _____

OBJECTIVE 1

State general job safety rules. For each word or group of words, write a safety rule that applies to that word or group.

GENERAL SAFETY

1. Close-fitting clothing — _____

2. Jewelry — _____

3. Tools or sharp objects — _____

4. Location of fire fighting and first-aid equipment — _____

TOOL AND EQUIPMENT SAFETY

5. Guards and safety devices — _____

6. Proper storage areas — _____

_____

_____

7. Material being drilled — _____

_____

_____

WORK AREA SAFETY

8. Obstacles and spilled substances — _____

_____

_____

9. Aisles, exits and traffic areas — _____

_____

_____

VEHICLE SAFETY

10. "Spotter" — _____

_____

_____

11. Exhaust-removal equipment — _____

_____

_____

12. Moving parts — _____

_____

_____

13. Safety belt — _____

_____

_____

CNG SAFETY

14. Standards and regulations — _____

_____

_____

15. Ventilation — _____

_____

_____

16. Inspect — _____

_____

_____

17. Battery ground cable — _____

_____

_____

18. Drilling — _____

_____

_____

OBJECTIVE 2

Determine colors used in the safety color code. Write the correct letter in each numbered blank.

_____1. Fire protection equipment and its location is identified by

a. Federal Safety RED
b. Federal Safety YELLOW
c. Federal Safety BLACK AND WHITE
d. Federal Safety BLUE

_____2. Traffic flow paths, storage areas, and housekeeping equipment are indicated by

a. Federal Safety RED
b. Federal Safety YELLOW
c. Federal Safety BLACK AND WHITE
d. Federal Safety BLUE

_____3. First-aid equipment and its location is identified by

a. Federal Safety BLUE
b. Federal Safety YELLOW
c. Federal Safety ORANGE
d. Federal Safety GREEN

_____4. Tags used to identify equipment that should not be started, used or moved are identified by

a. Federal Safety RED
b. Federal Safety BLUE
c. Federal Safety YELLOW
d. Federal Safety PURPLE

OBJECTIVE 3

Determine the correct fire extinguisher to use for various classes of fires. In each blank, write the letter of the correct class of fire involved: A, B, C or D.

_____1. Fire in a filing cabinet for old invoices

_____2. Smoke coming from the motor of an exhaust fan

_____3. Metal studs burning near a reinforcement weld

_____4. Fire in the carburetor of a gasoline-powered service vehicle

_____5. Smoke coming from a barrel filled with oily rags

_____6. Smoldering insulation around a shorted electrical outlet

_____7. A can of paint thinner spills and the thinner bursts into flames when someone drops a lighted cigarette onto it

_____8. A coffee pot hot plate is left unattended and ignites paper on a bulletin board

_____9. A can of paint thinner explodes into flames and ignites a panel of exposed electrical circuits

OBJECTIVE 4 **List in order the basic steps in using a portable fire extinguisher.**

1. P — _____

_____

_____

2. P — _____

_____

_____

3. P — _____

_____

_____

4. S — _____

_____

_____

NOTICE The following objective is not a part of the Written Test.

OBJECTIVE 5 **Properly lift a heavy object.** RATING _____

REVIEW GENERAL SAFETY PRACTICES 2

OBJECTIVE 1

1. Wear close-fitting clothing appropriate for the work.
2. Remove all jewelry before working.
3. Do not carry tools or sharp objects in your pockets.
4. Know the location of fire fighting and first-aid equipment.
5. Keep guards and safety devices in place on all equipment.
6. Store tools and equipment in their proper storage areas when not in use.
7. Do not hold your hand behind material being drilled.
8. Clear floors of obstacles and spilled substances immediately.
9. Keep all aisles, exits and traffic areas clear.
10. Use a "spotter" to help you maneuver or park a vehicle in a close area.
11. Do not leave a vehicle running indoors without adequate exhaust-removal equipment in place.
12. Be careful of moving parts and parts that heat up during engine operation.
13. Wear your safety belt *whenever* you ride in or drive a vehicle.
14. Follow all applicable standards and regulations.
15. Make sure that adequate ventilation is in place.
16. Inspect all components to be sure that they are not damaged.
17. Disconnect the battery ground cable before doing any wiring.
18. Before drilling, make sure that you will not hit the vehicle's gasoline fuel tank, fuel line or other wiring.

OBJECTIVE 2

1. a
2. c
3. d
4. b

OBJECTIVE 3

1. A
2. C
3. D
4. B
5. B
6. C
7. B
8. A
9. B and C

OBJECTIVE 4

1. P — PULL the pin at the top of the extinguisher that keeps the handle from being pressed. Break the plastic or thin wire inspection band.
2. P — POINT the nozzle or outlet toward the fire.

3. P — PRESS the handle above the carrying handle to discharge the contents inside. Release the handle to stop the discharge at any time.
4. S — SWEEP the nozzle back and forth at the base of the flames to speed the extinguishing agent.

OBJECTIVE SHEET

INTRODUCTION TO CNG INSTALLATION 3

INTRODUCTION

The use of compressed natural gas, or "CNG," as an alternative fuel in vehicles is growing. CNG systems can be installed in cars, in trucks large and small, and even on school buses. A vehicle can also be converted to run on CNG only (a "dedicated" CNG vehicle), or on either CNG or gasoline at the flip of a switch. In addition, installing a CNG system does not involve any major engine modifications. The basic routine for installing a CNG system will work on all vehicles.

This unit must be studied with the instructional videotape *Compressed Natural Gas Installation.*

UNIT OBJECTIVE

After completing this unit and viewing the instructional videotape *Compressed Natural Gas Installation: Introduction to CNG Installation,* you will be ready to study the specific jobs involved in installing a CNG system.

SPECIFIC OBJECTIVES

After completing this unit, you will be able to

1. Explain how a CNG system operates.
2. List benefits of CNG over gasoline.
3. Identify characteristics of CNG.
4. State prerequisite skill areas for installing a CNG system properly and safely.
5. State basic jobs involved in installing a CNG system.
6. List basic questions for evaluating a vehicle for CNG installation.
7. Describe two systems for refilling a CNG fuel system.

SUGGESTED ACTIVITIES	INTRODUCTION TO CNG INSTALLATION 3

PREPARATION

- Supplement this unit with additional resources.

Publications

— *Fact Sheets NGV 1-1, 2-1, 3-1, 4-1, 5-1, and 7-1.* From the American Gas Association, 1515 Wilson Boulevard, Arlington, VA 22209.

Media

— *Compressed Natural Gas Installation* instructional videotape. Available from the Oklahoma Department of Vocational and Technical Education, Resale Division, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Review the unit and plan your presentation.

— Estimate the amount of material that can be covered in each class session.

— Identify objectives that you can supplement with other resources.

— Invite guest speakers in advance.

- Design transparencies and handouts to reinforce the objectives in each unit, to provide additional information, or to facilitate in-class activities.

DELIVERY

Objective 1

- Illustrate the operation of a CNG system using sample CNG components, such as regulators, if possible.

Objective 2

- Explain why each item is a benefit.
- Ask participants about their interest in CNG as an alternative fuel for vehicles.

Objective 3

- Emphasize the potential hazards of working with CNG. For example, although CNG will travel upward in the event of a leak, it may be under as much as three thousand pounds of pressure. This flow could be very dangerous if a technician is not careful!

- Discuss the implications of the characteristics of CNG.

Objective 4

- Relate some of the listed skill areas to the CNG installation process. How are these skills important in CNG installation?

Objective 5

- State that the instructional videotape *Compressed Natural Gas Installation* will show each of these basic jobs being performed on a vehicle.

Objective 6

- Discuss the importance of each question. Give more examples, if possible.

Objective 7

- Show the first part of the instructional videotape *Compressed Natural Gas Installation: Introduction to CNG Installation.*

EVALUATION

Written Test

- Give the Written Test after presenting the unit, but not earlier than the next class session.

- Remind participants that the questions and required performance on the Written Test match the Specific Objectives stated at the beginning of the unit.

- Review individual and group performance in order to evaluate teaching methods. Adjust your approach as needed.

UNIT REFERENCES

- *Compressed Natural Gas Installation* instructional videotape. Stillwater, Oklahoma: Oklahoma Department of Vocational and Technical Education, 1991.
- *Fact Sheets NGV 1-1, 2-1, 3-1, 4-1, 5-1, and 7-1.* American Gas Association, October 1989.

INFORMATION SHEET	INTRODUCTION TO CNG INSTALLATION 3

OBJECTIVE 1

Explain how a CNG system operates.

CNG is stored in an approved fuel tank mounted under the frame of the vehicle (such as a bus or large truck), in the bed of a pickup truck, or in the trunk of a car. When the vehicle is started, the CNG flows through a stainless steel high-pressure fuel line along the underside of the vehicle from the CNG fuel tank to a regulator. This regulator includes a first-stage or high-pressure regulator and a second-stage or low-pressure regulator. The first-stage regulator brings the CNG down from as much as 3,000 pounds of pressure to about 40-100 pounds (depending on the brand used); the second-stage regulator brings the CNG down even more, to about 3-5 *ounces* of pressure. From the regulator, the CNG enters the engine's combustion chamber and is ignited to create power. (Unlike gasoline, which must be vaporized before it will ignite, CNG is already in the form of a gas when it enters the chamber.)

OBJECTIVE 2

List benefits of CNG over gasoline.

- CNG is a cleaner fuel than gasoline.

  NOTE: CNG can reduce emissions of carbon monoxide (CO) and other pollutants. CNG also releases practically no particles into the air. Because CNG is a cleaner fuel than gasoline, it can increase engine life, reduce pollution, and help reduce vehicle operating and maintenance costs.

- CNG burns more efficiently than gasoline.

  NOTE: Gasoline must be vaporized before it will ignite. However, CNG is already in the form of a gas when it enters the combustion chamber.

- A CNG system can extend the driving range of a vehicle.

  NOTE: The CNG system does not replace the vehicle's gasoline system (in a vehicle converted to run on either CNG or gasoline). The conversion equipment can also be transferred from one vehicle to another.

- CNG is generally a safer fuel than gasoline.

CAUTION

The properties of CNG make it a generally safer fuel than gasoline. However, CNG must always be handled with respect. CNG tanks may contain as much as three thousand pounds of pressure.

- CNG costs less than an equivalent gallon of gasoline.
- The United States has a large supply of natural gas.

OBJECTIVE 3 **Identify characteristics of CNG.**

- CNG is lighter than air.

  NOTE: In the event of a leak, CNG will travel upward. It will not create a puddle like gasoline or hang in the air as a dangerous vapor.

- CNG has an ignition temperature of about 1200 degrees Fahrenheit.

  NOTE: CNG is more difficult to ignite than gasoline, which has an ignition temperature of about 600 degrees Fahrenheit.

- CNG has a limited flammability range in air of about 5% to 15%.

  NOTE: This means that CNG will not burn if its concentration in air is below about 5% and above about 15%.

- CNG has an octane rating of 130.
- CNG is not toxic or corrosive.

CAUTION

Although CNG is not toxic, it can cause asphyxiation if it displaces the normal concentration of oxygen in air in an area that is not adequately ventilated.

- CNG is colorless and tasteless.

  NOTE: An odor is added to CNG so that you can detect the presence of the gas.

OBJECTIVE 4

State prerequisite skill areas for installing a CNG system properly and safely.

NOTE: You must also satisfy all of the requirements for certification in the Alternative Fuels Technician Certification Act.

ELECTRICAL SYSTEMS EXPERIENCE

- General electrical system diagnosis
- Battery diagnosis and repair
- Starting system diagnosis and repair
- Charging system diagnosis and repair
- Lighting system diagnosis and repair
- Gauges and warning devices
- Driver information systems diagnosis and repair
- Horn and wiper/washer system diagnosis and repair
- Accessories diagnosis and repair

ENGINE PERFORMANCE EXPERIENCE

- General engine diagnosis
- Ignition system diagnosis and repair
- Fuel and exhaust system diagnosis and repair
- Emission control system diagnosis and repair
- Engine-related service

OBJECTIVE 5 **State basic jobs involved in installing a CNG system.**

1. Mounting the CNG fuel tank
2. Installing the CNG regulator
3. Installing the CNG fuel line
4. Connecting the CNG system wiring
5. Installing the CNG carburetor
6. Filling the CNG fuel tank
7. Testing and adjusting the system

OBJECTIVE 6 **List basic questions for evaluating a vehicle for CNG installation.**

Q Does the engine have low mileage?

NOTE: If the engine has over 50,000 miles on it, you may want to do a compression test before you install a CNG system.

Q Does the engine have good compression?

Q Does the engine have good vacuum?

Q Are any existing parts defective or damaged?

Q Are wires and hoses in good condition?

Q Are common maintenance items in good condition?

EXAMPLE: Wires, hoses, etc.

Q Does the vehicle have room for the CNG fuel tank(s)?

OBJECTIVE 7 **Describe two systems for refilling a CNG fuel system.**

"Fast-fill" — A method that uses CNG storage containers to refill the CNG fuel tank and takes about as much time as filling a gasoline tank

"Slow-fill" — A method that does not use CNG storage tanks to refill the CNG fuel tank and can take a longer period of time, from minutes to hours

INTRODUCTION TO CNG INSTALLATION

NAME _____ SCORE _____

OBJECTIVE 1

Explain how a CNG system operates. Include as many main points as possible.

_____

_____

_____

_____

_____

_____

_____

_____

OBJECTIVE 2

List benefits of CNG over gasoline. List four (4) benefits.

1. _____
2. _____
3. _____
4. _____

OBJECTIVE 3

Identify characteristics of CNG. Write the correct letter in the blank beside each numbered item.

_____1. CNG is ___.

a. lighter than air
b. heavier than air
c. as light as air
d. as light as gasoline

_____2. CNG has an ignition temperature of about ___.

a. 600 degrees Fahrenheit
b. 900 degrees Fahrenheit
c. 1200 degrees Fahrenheit
d. 1500 degrees Fahrenheit

_____3. CNG has a limited flammability range in air of about ___.

a. 5% to 10%
b. 5% to 15%
c. 5% to 20%
d. 10% to 15%

_____4. CNG has an octane rating of ___.

a. 100
b. 110
c. 120
d. 130

_____5. CNG is ___.

a. toxic
b. corrosive
c. colorless and tasteless
d. as "dirty" as gasoline

OBJECTIVE 4

State prerequisite skill areas for installing a CNG system properly and safely. Write the requested number of areas under each heading.

ELECTRICAL SYSTEMS EXPERIENCE

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

7. _____

ENGINE PERFORMANCE EXPERIENCE

1. _____
2. _____
3. _____
4. _____

OBJECTIVE 5

State basic jobs involved in installing a CNG system. State the jobs in any order.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

OBJECTIVE 6

List basic questions for evaluating a vehicle for CNG installation. List five (5) questions.

1. _____
2. _____
3. _____
4. _____
5. _____

OBJECTIVE 7

Describe two systems for refilling a CNG fuel system.

1. _____ — _____

_____

_____

2. _____ — _____

_____

_____

OBJECTIVE 1

CNG is stored in an approved fuel tank mounted under the frame of the vehicle (such as a bus or large truck), in the bed of a pickup truck, or in the trunk of a car. When the vehicle is started, the CNG flows through a stainless steel high-pressure fuel line along the underside of the vehicle from the CNG fuel tank to a regulator. This regulator includes a first-stage or high-pressure regulator and a second-stage or low-pressure regulator. The first-stage regulator brings the CNG down from as much as 3,000 pounds of pressure to about 40-100 pounds (depending on the brand used); the second-stage regulator brings the CNG down even more, to about 3-5 *ounces* of pressure. From the regulator, the CNG enters the engine's combustion chamber and is ignited to create power.

OBJECTIVE 2

Any four (4) of the following:

- CNG is a cleaner fuel than gasoline.
- CNG burns more efficiently than gasoline.
- A CNG system can extend the driving range of a vehicle.
- CNG is generally a safer fuel than gasoline.
- CNG costs less than an equivalent gallon of gasoline.
- The United States has a large supply of natural gas.

OBJECTIVE 3

1. a
2. c
3. b
4. d
5. c

OBJECTIVE 4

The requested number of areas from the following:

ELECTRICAL SYSTEMS EXPERIENCE

- General electrical system diagnosis
- Battery diagnosis and repair
- Starting system diagnosis and repair
- Charging system diagnosis and repair
- Lighting system diagnosis and repair
- Gauges and warning devices
- Driver information systems diagnosis and repair
- Horn and wiper/washer system diagnosis and repair
- Accessories diagnosis and repair

ENGINE PERFORMANCE EXPERIENCE

- General engine diagnosis
- Ignition system diagnosis and repair
- Fuel and exhaust system diagnosis and repair
- Emission control system diagnosis and repair
- Engine-related service

OBJECTIVE 5

In any order:

1. Mounting the CNG fuel tank
2. Installing the CNG regulator
3. Installing the CNG fuel line
4. Connecting the CNG system wiring
5. Installing the CNG carburetor
6. Filling the CNG fuel tank
7. Testing and adjusting the system

OBJECTIVE 6

Any five (5) of the following:

- Does the engine have low mileage?
- Does the engine have good compression?
- Does the engine have good vacuum?
- Are any existing parts defective or damaged?
- Are wires and hoses in good condition?
- Are common maintenance items in good condition?
- Does the vehicle have room for the CNG fuel tank(s)?

OBJECTIVE 7

- *"Fast-fill"* — A method that uses CNG storage containers to refill the CNG fuel tank and takes about as much time as filling a gasoline tank
- *"Slow-fill"* — A method that does not use CNG storage tanks to refill the CNG fuel tank and can take a longer period of time, from minutes to hours

OBJECTIVE SHEET	**INSTALL A CNG SYSTEM** 4

INTRODUCTION

Installing a CNG system does not involve any major engine modifications. The basic routine for installing a CNG system will work on all vehicles.

This unit must be studied with the instructional videotape *Compressed Natural Gas Installation.*

UNIT OBJECTIVE

After completing this unit and viewing the instructional videotape *Compressed Natural Gas Installation,* you will be able to install a CNG system.

SPECIFIC OBJECTIVES

After completing this unit, you will be able to

1. State the accepted standard for the installation of CNG fuel systems for vehicles.
2. Identify selected standards for installing the CNG fuel tank.
3. Explain the importance of sealing and venting CNG components mounted within a closed compartment.
4. Identify selected standards for sealing and venting CNG components mounted within a closed compartment.
5. Explain how the regulators operate in a CNG system.
6. Identify selected standards for installing regulators.
7. State three safety rules to follow while installing the CNG regulator.
8. State the specifications for high-pressure fittings and tubing used in the CNG fuel line.
9. List possible locations for stress loops in the fuel line.
10. Identify selected standards for installing the CNG fuel line and fittings.
11. State the major steps in connecting the CNG system wiring.

12. Explain the function of major electronics add-ons in a CNG system.

13. State general safety rules to follow while connecting the CNG system wiring.

14. Identify selected standards for testing the CNG system.

15. Identify the order of basic steps for testing and adjusting the system.

16. Mount the CNG fuel tank. (Job Sheet 1)

17. Seal and vent a CNG fuel tank mounted within a closed compartment (such as the trunk of a car). (Job Sheet 2)

18. Install the CNG regulator. (Job Sheet 3)

19. Install the CNG fuel line. (Job Sheet 4)

20. Install the computer signal modification device. (Job Sheet 5)

21. Install the dual curve ignition. (Job Sheet 6)

22. Install the relay. (Job Sheet 7)

23. Install the fuel gauge and CNG/gasoline switch. (Job Sheet 8)

24. Install the CNG carburetor. (Job Sheet 9)

25. Purge and fill the system. (Job Sheet 10)

PREPARATION

- Supplement this unit with additional resources.

  Publications

  — *NFPA 52: Compressed Natural Gas (CNG) Vehicular Fuel Systems* (current edition). Contact the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

  Media

  — *Compressed Natural Gas Installation* instructional videotape. Available from the Oklahoma Department of Vocational and Technical Education, Resale Division, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Review the unit and plan your presentation.

  — Estimate the amount of material that can be covered in each class session.

  — Identify objectives that you can supplement with other resources.

  — Invite guest speakers in advance.

- Design transparencies and handouts to reinforce the objectives in each unit, to provide additional information, or to facilitate in-class activities.

DELIVERY

Objective 1

- Refer to Section 6 of the Oklahoma "Alternative Fuels Technician Certification Act."

- Show an example of *NFPA 52* and outline its contents. Tell participants how to obtain copies from NFPA:

  NFPA 52: Compressed Natural Gas (CNG) Vehicular Fuel Systems (current edition). Contact the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

Objectives 2 through 4

- Discuss the importance of each selected standard.
- Refer back to the characteristics of CNG.
- Show the instructional videotape *Compressed Natural Gas Installation: Mount the CNG Fuel Tank.*
- Introduce Job Sheet 1 and Job Sheet 2.

Objectives 5 through 7

- Show the components in a typical regulator kit.
- Discuss the importance of each selected standard.
- Show the instructional videotape *Compressed Natural Gas Installation: Install the CNG Regulator.*
- Refer to the manufacturer's installation instructions.
- Introduce Job Sheet 3.

Objectives 8 through 10

- Demonstrate the use of proper tube-bending equipment. Allow participants to practice.
- Discuss the importance of each selected standard.
- Show the instructional videotape *Compressed Natural Gas Installation: Install the CNG Fuel Line.*
- Introduce Job Sheet 4.

Objectives 11 through 13

- Explain that the job of wiring will usually take more time than any other job in the installation process.
- Show the different components as they appear direct from the manufacturer.
- Show the instructional videotape *Compressed Natural Gas Installation: Connect the CNG System Wiring.*

- Refer to the manufacturer's installation instructions.
- Introduce Job Sheet 5, Job Sheet 6, Job Sheet 7, and Job Sheet 8.
- Show the components in a carburetor kit.
- Show the instructional videotape *Compressed Natural Gas Installation: Install the CNG Carburetor.*
- Introduce Job Sheet 9.

Objective 14

- Show examples of commercially-available liquid leak detector.
- Show the instructional videotape *Compressed Natural Gas Installation: Fill the CNG Fuel Tank.*
- Introduce Job Sheet 10.

Objective 15

- Show the instructional videotape *Compressed Natural Gas Installation: Test and Adjust the System.*
- Encourage participants to take notes on the adjustments described in the videotape.
- Discuss common considerations for troubleshooting.

APPLICATION

Objectives 16 through 25

- Show the appropriate parts of the instructional videotape *Compressed Natural Gas Installation* before introducing each Job Sheet.
- Allow participants to review the specific part of the instructional videotape, and practice each procedure if possible, until they are ready to be evaluated on the Practical Test for each Job Sheet procedure.

EVALUATION

Practical Test

- Explain the purpose of the Practical Test.

- Explain the rating scale.
- Complete each Practical Test for each participant.
- Reteach and retest if needed.

Written Test

- Give the Written Test after presenting the unit, but not earlier than the next class session.
- Remind participants that the questions and required performance on the Written Test match the Specific Objectives stated at the beginning of the unit.
- Review individual and group performance in order to evaluate teaching methods. Adjust your approach as needed.

UNIT REFERENCES

- "Alternative Fuels Technician Certification Act" (Section 420.52 of Title 52 of the Oklahoma Statutes).
- *NFPA 52 Compressed Natural Gas (CNG) Vehicular Fuel Systems* (1988 Edition), National Fire Protection Association, 1988.
- *Compressed Natural Gas Installation* instructional videotape. Stillwater, Oklahoma: Oklahoma Department of Vocational and Technical Education, 1991.

INFORMATION SHEET	INSTALL A CNG SYSTEM 4

OBJECTIVE 1

State the accepted standard for the installation of CNG fuel systems for vehicles.

National Fire Protection Association (NFPA) Pamphlet No. 32 is the accepted standard in Oklahoma, as stated in the Alternative Fuels Technician Certification Act (Section 420.52 of Title 52 of the Oklahoma Statutes).

NOTE: The Oklahoma Corporation Commission is authorized to adopt and develop rules or specifications relating to safety in the manufacture, assembly, sale, installation and use of alternative fuel systems for vehicles. The Commission is also authorized to modify or amend such rules or specifications.

OBJECTIVE 2

Identify selected standards for installing the CNG fuel tank.

NOTE: This objective is not a substitute for the complete standards in *NFPA 52* or any other requirements.

- Locate the fuel tank where any damage from a collision can be minimized.
- Locate the fuel tank where the road clearance is adequate.
- Locate the fuel tank where it is accessible and clear of obstructions.
- Locate the fuel tank not ahead of the front axle or behind the rear bumper mounting face.
- Install a manually-operated container valve on each CNG fuel tank.
- Locate the container valve where it is protected from damage.

  EXAMPLE: The valve may be protected using the vehicle structure, valve protectors or a metal shield.

- Locate the fuel tank where the tank, valve and connections can be easily inspected and serviced.

  NOTE: Remember that the conversion equipment on vehicles fueled by alternative fuels must be inspected once a year (as defined in the Alternative Fuels Technician Certification Act).

- Label the installed CNG fuel tank with the words "CNG ONLY" as a decal or a stencil.

  NOTE: The letters should be at least one inch high, in a contrasting color, and visible after the fuel tank is installed.

OBJECTIVE 3

Explain the importance of sealing and venting CNG components mounted within a closed compartment.

Although CNG is not toxic, it can cause asphyxiation if it displaces the normal concentration of oxygen in air in an area that does not have adequate ventilation. If you are mounting the CNG fuel tank(s) in the trunk of a car, then enclose the shut-off valve and all connections in an approved plastic bag. This bag will help prevent any gas leaks from entering the car. Instead, the gas will be contained in the bag and will be released into the outside air through the same hole made in the floorboard for the CNG fuel line.

OBJECTIVE 4

Identify selected standards for sealing and venting CNG components mounted within a closed compartment.

NOTE: This objective is not a substitute for the complete standards in *NFPA 52* or any other requirements.

- Vent all pressure relief devices and pressure-carrying components installed within a closed compartment to the outside of the vehicle.

  EXAMPLE: Valves, fittings, and fuel lines mounted in the trunk of a car or other closed space

- Do not vent the CNG valves, fittings, and fuel lines into a wheel well.

OBJECTIVE 5 **Explain how the regulators operate in a CNG system.**

When the vehicle is started, the CNG flows through a stainless steel high-pressure fuel line along the underside of the vehicle from the CNG fuel tank to a regulator. This regulator includes a first-stage or high-pressure regulator. The first-stage regulator brings the CNG down from as much as 3,000 pounds of pressure to about 40-100 pounds (depending on the brand used); the second-stage regulator brings the CNG down even more, to about 3-5 *ounces* of pressure.

OBJECTIVE 6 **Identify selected standards for installing regulators.**

NOTE: This objective is not a substitute for the complete standards in *NFPA 52* or any other requirements.

- Install regulators so that they will not freeze when CNG passes through them.

  EXAMPLE: Heater hoses can be attached to the regulator to prevent freezing.

- Install regulators so that their weight is not placed on, or supported by, the CNG fuel line.

- Protect pressure gauges from damage caused by vibration or unsecured objects.

OBJECTIVE 7 **State three safety rules to follow while installing the CNG regulator.**

- Mount the regulator away from a heat source.

- Be sure that a pressure-sensitive and temperature-sensitive pressure relief device is installed at the CNG fuel tank.

- Use high-pressure fittings and tubing that meet the following specifications in all fuel lines: stainless steel fittings, 10,000 psi tested; and stainless steel tubing, 6,000 psi tested.

OBJECTIVE 8 **State the specifications for high-pressure fittings and tubing used in the CNG fuel line.**

For stainless steel fittings: 10,000 psi tested

For stainless steel tubing: 6,000 psi tested

BEST COPY AVAILABLE

OBJECTIVE 9 **List possible locations for stress loops in the fuel line.**

- Before connections at the regulator
- At the shut-off valve at the fuel tank
- Midway on long runs of tubing
- In the section of the fuel line connecting the tanks (on vehicles with more than one CNG fuel tank side-by-side, such as on a larger truck or in the trunk of a car)

OBJECTIVE 10 **Identify selected standards for installing the CNG fuel line and fittings.**

NOTE: This objective is not a substitute for the complete standards in *NFPA 52* or any other requirements.

- Do not use aluminum or copper fuel lines or fittings between the CNG fuel tank and the first-stage regulator.
- Make sure that all fuel lines and fittings are clear of obstructions.

  EXAMPLE: Steel shavings from cutting the fuel line, excess fitting sealant

- Protect the fuel line with grommets as needed to prevent abrasion wherever the line passes through a panel.

  EXAMPLE: Wherever the line passes through a floor panel, a firewall panel, or a bulkhead

- Support the fuel line every 24 inches or less.

  NOTE: This support, such as in the form of cushioned adel clamps, can protect the CNG fuel line from the effects of vibration and can keep the line from being damaged by hanging or dragging.

- Locate all connections where they are accessible.

OBJECTIVE 11 **State the major steps in connecting the CNG system wiring.**

1. Install a computer signal modification device.
2. Install a dual curve ignition system.
3. Install a relay.
4. Install a fuel gauge and CNG/gasoline switch.

OBJECTIVE 12 **Explain the function of major electronics add-ons in a CNG system.**

Computer signal modification device — This unit provides information to the vehicle's computer, so that the computer responds properly when the vehicle is operating on CNG instead of gasoline. Specifically, this unit prevents false malfunction codes from the oxygen sensor, prevents false warning codes relating to exhaust gas recirculation (EGR), prevents false warning codes relating to the "knock sensor," and prevents the computer from retarding the spark timing on CNG.

Dual curve ignition — This unit allows the engine ignition to advance the timing fifteen (15) degrees when running on CNG, and returns it to OEM basic timing when running on gasoline.

Relay — This unit facilitates the switch to or from CNG by "carrying the load."

Fuel gauge — This unit shows the amount of CNG in the fuel tank, from "full" to "empty." It may be a separate LED unit for CNG only or a dual display for gasoline and CNG.

CNG/Gasoline switch — This unit allows the driver to switch from gasoline to CNG, and back again, without stopping the vehicle.

OBJECTIVE 13 **State general safety rules to follow while connecting the CNG system wiring.**

- Always install the computer signal modification device and the dual curve ignition away from heat sources.

BEST COPY AVAILABLE

- Solder all wire connections with rosin core solder.

  NOTE: Do not use acid-core solder. Also, do not use quick-connects or solderless connectors. These connectors can come loose or cut into the wiring, causing unacceptable levels of resistance.

- Wrap connections with heat-shrink tubing or tape.

- Relocate the ignition coil at least six inches away from the distributor.

  NOTE: This will prevent magnetic field interference.

OBJECTIVE 14 **Identify selected standards for testing the CNG system.**

NOTE: This objective is not a substitute for the complete standards in *NFPA 52* or any other requirements.

- Check every connection for leaks, using commercially-available liquid leak detector or a leak detector instrument, after the CNG system is installed and after some pressure is added.

- Be sure that you have adequate ventilation when leak testing with CNG.

- If the CNG fuel tank is damaged in an accident or fire, replace the fuel tank or remove it, inspect it, and retest it as required before using it again.

- If any part of the CNG system is damaged in an accident or fire, retest the system before returning the vehicle to service.

OBJECTIVE 15 **Identify the order of basic steps for testing and adjusting the system.**

NOTE: You may have to do some troubleshooting after the installation before getting your vehicle to run smoothly.

1. Adjust the pressures on the regulators. Adjust the pressure on the first-stage regulator (with its cap removed) until it reads in the range of 40-100 pounds (depending on the brand used).

2. Start the vehicle on CNG.

3. Adjust the pressure on the second-stage regulator (with its cap removed) until it reads in the range of 3-5 ounces or 2-7 inches of water column.

4. Stop the engine, disconnect the dual curve ignition, start the vehicle on gasoline, advance the timing, then recheck the timing.

5. Reconnect the dual curve.

   NOTE: The dual curve will return to O.E.M. standard timing.

6. Switch to CNG, then set the idle speeds on CNG and adjust the load screws.

7. Apply the CNG label on the right rear of the vehicle, above the bumper.

8. Test drive the vehicle to determine that it is operating properly. Use a dynamometer, if available, for faster and more precise adjustments.

CAUTION

Always wear proper hearing protection when using a dynamometer.

JOB SHEET 1	INSTALL A CNG SYSTEM	4

OBJECTIVE 16

Mount the CNG fuel tank.

INTRODUCTION

After evaluating the vehicle and deciding that the vehicle can operate on CNG, you can begin installing the system by mounting the CNG fuel tank. This fuel tank will be located in different places on different types of vehicles. For example, the tank can be mounted under the frame of the vehicle (such as a bus or large truck), in the bed of a smaller truck, or in the trunk of a car. Brackets must be mounted on the vehicle to hold the CNG fuel tank. The following steps apply to a single CNG fuel tank mounted in the bed of a truck. You may have to adapt these steps slightly for other types of mounting situations.

View the instructional videotape *Compressed Natural Gas Installation: Mount the CNG Fuel Tank* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- An approved fuel tank for a CNG vehicular fuel system (empty)
- Brackets
- Rubber belting
- Weatherstrip glue
- Grade 8 bolts, backing plates
- Power drill
- Wrenches
- Approved safety glasses

PROCEDURE

1. Determine a location for the CNG fuel tank.

   NOTE: Regardless of the type of vehicle being used, the CNG fuel tank will cause some space to be lost. Be sure that this is understood in advance by the owner of the vehicle.

2. Before mounting the brackets, cut strips of rubber belting for each bracket for the surfaces that will touch the CNG fuel tank.

   NOTE: The rubber belting will help prevent damage to the fiberglass wrap on the fuel tank.

3. Glue the belting to both halves of each bracket with weatherstrip glue.

4. Drill holes for mounting the brackets, then mount the bottom half of each bracket using grade 8 bolts. Also use backing plates when installing on sheet metal.

CAUTION

Before drilling, make sure that you will not hit the vehicle's gasoline fuel tank, fuel line or other wiring.

5. Carefully lift the tank onto the brackets.

CAUTION

Before handling, make sure that the CNG fuel tank is empty. Also, be careful not to damage the fiberglass wrap on the tank. If you damage this wrap, you cannot use the fuel tank. Always handle CNG fuel tanks with respect.

6. Position the tank with the shut-off valve handle facing upward.

NOTE: Locate the shut-off valve where it can receive the fuel line, which will connect to the valve through a hole in the floor. The valve must also be located where it can be easily serviced.

7. With the tank in position, mount the top half of each bracket with washers and bolts at the top and bottom.

NOTE: Insert the top bolts in the opposite direction from the bottom bolts. This will add to the strength of the mounting.

8. Tighten all of the bolts.

9. Label the fuel tank "CNG ONLY" in accordance with accepted standards.

NOTE: See *NFPA 52* for complete requirements.

10. Review your work for compliance with accepted standards and other requirements.

11. Clean the work area and return equipment and materials to their proper storage.

JOB SHEET 2	INSTALL A CNG SYSTEM 4

OBJECTIVE 17

Seal and vent a CNG fuel tank mounted within a closed compartment (such as the trunk of a car).

INTRODUCTION

The standards in *NFPA 52* provide for the installation of CNG fuel tanks within the driver or passenger compartment, as long as all of the connections to the tanks are either outside of the compartments or are sealed and vented from the compartment.

View the instructional videotape *Compressed Natural Gas Installation: Mount the CNG Fuel Tank* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- Double-adhesive tape
- Plastic bag material
- Clamps

PROCEDURE

1. Wrap double-adhesive tape around the base of the valve.
2. Enclose the valve and all fittings completely; be sure that all fittings are tight and that the bag is gathered tightly.
3. Clamp the bag at the valve and at the grommet where the fuel line leaves the trunk.

   NOTE: Grommets protect the fuel line wherever the line passes through a floor panel, a firewall panel, or a bulkhead. Do not vent the fuel tank into a wheel well.
4. Review your work for compliance with accepted standards and other requirements.
5. Clean the work area and return equipment and materials to their proper storage.

OBJECTIVE 18

Install the CNG regulator.

INTRODUCTION

After mounting the CNG fuel tank, you are ready to look "under the hood." A good place to start is the job of installing the regulator. A CNG system actually includes two regulators: a first-stage or high-pressure regulator, and a second-stage or low-pressure regulator. The regulator assembly is also connected to the vehicle's heater hoses. These heater hoses will help prevent freezing when the CNG passes through the regulator.

View the instructional videotape *Compressed Natural Gas Installation: Install the CNG Regulator* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- Regulator kit
- Approved fitting sealant
- Power drill
- Lock washers, flat washers and shims
- Container for drained antifreeze/coolant
- New heater hoses
- Cutting tool (for snipping hoses)

PROCEDURE

MOUNTING THE REGULATOR

NOTE: Always inspect new components to be sure that they are not damaged and are free of defects. Follow the manufacturer's instructions, in addition to these general steps.

1. Before assembling the regulator, apply an approved fitting sealant to the fitting threads at both ends.

CAUTION

Be sure that the sealant does not cover any part of the opening in the fitting. Fittings alone are not airtight; the sealant will increase the sealing capability of the fitting.

2. Install the fitting between the first-stage regulator and the second-stage regulator at the incoming end of the second-stage regulator (indicated by an arrow showing the direction of flow of the incoming CNG).

CAUTION

Be aware of the correct direction of flow on *both* regulators as you install the fitting. The first-stage regulator may have more than one inlet and outlet. Be sure that you install the fitting at the correct point on the regulators.

3. Attach the fill valve and check valve, the pressure gauge and the shut-off valve according to the manufacturer's instructions.

4. Determine a location for the regulator.

NOTE: Finding the best location for the regulator involves trial and error. The regulator must be located where it can be easily serviced and where it will not interfere with the operation of any other engine components. You may also have to relocate the battery or other O.E.M. components to make room for the regulator. Do a "rough fit" of the regulator in different locations, before you choose a final location.

5. Drill holes for the regulator bracket.

NOTE: Place fender covers on the vehicle where needed before you work at the vehicle.

6. Mount the regulator with the round side facing either upward or to one side.

CAUTION

If the round side is facing forward, the stop-and-go action of the vehicle could induce a surge when running on CNG.

7. Secure and level the regulator.

NOTE: Secure the regulator with a flat washer and a lock washer on each bolt. The lock washer will hold the bolt in place, while the flat washer will help keep the bolt from being pulled through the hole. Use shims to level the regulator.

8. Label the shut-off valve.

CONNECTING THE REGULATOR TO HEATER HOSES

1. Drain the antifreeze/coolant from the system.
2. Cut into an original heater hose and clamp a "T" in place.
3. Attach a new heater hose from the first-stage regulator to the "T" in the original line.
4. Clamp a water shut-off valve in place between the new heater hose and the "T."

   NOTE: This valve will control the amount of heater water that passes through the regulator.
5. Cut into the other original heater hose and clamp a "T" in place, then attach a new hose from the regulator to this "T."

   NOTE: The heater hoses will help prevent freezing when the CNG passes through the regulator.
6. Safely route and secure the new hoses in split-loom tubing.
7. Replace the antifreeze/coolant.
8. Review your work for compliance with accepted standards and other requirements.
9. Clean the work area and return equipment and materials to their proper storage.

JOB SHEET 4	INSTALL A CNG SYSTEM 4

OBJECTIVE 19

Install the CNG fuel line.

INTRODUCTION

The CNG fuel line runs along the underside of the vehicle between the CNG fuel tank and the regulator. Cushioned adel clamps secure the line to the frame. In addition, grommets protect the fuel line wherever the line passes through a floor panel, a firewall panel, or a bulkhead. You can assemble and install the CNG fuel line at any time after mounting the fuel tank and the regulator.

View the instructional videotape *Compressed Natural Gas Installation: Install the CNG Fuel Line* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- Approved stainless steel tubing and fittings
- Measuring tape
- Tube-bending tool
- Clear vinyl tubing
- Cutting tool (for cutting steel tubing)
- Approved fitting sealant
- Adel clamps

PROCEDURE

1. Measure the approximate length of the fuel line from the location of the mounted regulator to the fuel tank shut-off valve (with about two feet of extra tubing added to your measurement, to account for bends and loops that you will make in the fuel line).

2. Cut the steel tubing to the required length.

   NOTE: Be sure that the fuel line is a single length of line, as far as possible. This will reduce the chances for leaks.

3. Spray lubricant into a length of clear vinyl tubing, then insert the fuel line.

   NOTE: This vinyl tubing is optional. However, it will better protect the fuel line and may provide an extra margin of safety.

4. Make stress loops where needed.

5. Apply an approved fitting sealant to fitting threads at both ends.

CAUTION

Fittings alone are not airtight. The sealant will increase the sealing capability of the fitting. Be sure that the sealant does not cover any part of the opening.

6. Bend the fuel line if necessary, using proper tube-bending equipment.

CAUTION

In many cases, you will have to bend the fuel line for a proper fit. However, be sure that you do not weaken the fuel line as a result.

7. Connect the fuel line tightly at the CNG fuel tank and at the regulator.

CAUTION

You should take fittings apart after tightening them, to make sure that the ferrules and the steel tubing seal properly. Reconnect the fittings after checking and be sure to torque the fitting to the manufacturer's specifications.

8. Secure the fuel line to the vehicle every 24 inches or less.

NOTE: Cushioned adel clamps can prevent rust from forming at the clamp.

9. Review your work for compliance with accepted standards and other requirements.

10. Pick up any remaining pieces of steel tubing.

CAUTION

Steel tubing on a floor can create a hazard.

11. Clean the work area and return equipment and materials to their proper storage.

OBJECTIVE 20

Install the computer signal modification device.

INTRODUCTION

View the instructional videotape *Compressed Natural Gas Installation: Connect the CNG System Wiring* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- Computer signal modification device
- Soldering gun and rosin core solder
- Split-loom tubing
- Heat-shrink tubing or tape
- Approved silicone sealant
- Power drill

PROCEDURE

CAUTION

Disconnect the battery ground cable before you do any wiring.

1. Make sure that the component is complete and is not damaged.

2. Apply silicone sealant around the edges of the unit.

   NOTE: You must seal this component twice: once before mounting and once after mounting. The sealant will help prevent moisture from entering the unit.

3. Mount the unit in a dry location away from heat sources.

   CAUTION

   Extreme temperatures can damage the unit.

4. Apply silicone sealant around the edges of the unit touching the vehicle.

5. Connect the unit to the oxygen sensor, to the EGR terminal, to the "knock sensor," to a 12-volt on/off source, and to the throttle position sensor according to the manufacturer's instructions.

   NOTE: These connections may be a soldered splice or a plug.

6. Wrap the connections with heat-shrink tubing or tape.

7. Enclose the wiring with split-loom tubing.

8. Review your work for compliance with accepted standards and other requirements.

9. Clean the work area and return equipment and materials to their proper storage.

JOB SHEET 6	INSTALL A CNG SYSTEM 4

OBJECTIVE 21

Install the dual curve ignition.

INTRODUCTION

View the instructional videotape *Compressed Natural Gas Installation: Connect the CNG System Wiring* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- Dual curve ignition kit
- Soldering gun and rosin core solder
- Split-loom tubing
- Heat-shrink tubing or tape
- Approved silicone sealant
- Power drill

PROCEDURE

CAUTION

Disconnect the battery ground cable before you do any wiring.

1. Make sure that the component is complete and is not damaged.
2. Apply silicone sealant around the edges of the unit.

   NOTE: You must seal this component twice: once before mounting and once after mounting. The sealant will help prevent moisture from entering the unit.
3. Mount the unit on the firewall in a dry location and away from heat sources.

   CAUTION

   Extreme temperatures can damage the unit.
4. Apply silicone sealant around the edges of the unit touching the vehicle.
5. Enclose the wiring with split-loom tubing.
6. Connect the wiring according to the manufacturer's instructions.
7. Clamp the wiring to the firewall.

8. Review your work for compliance with accepted standards and other requirements.

9. Clean the work area and return equipment and materials to their proper storage.

JOB SHEET 7	INSTALL A CNG SYSTEM 4

OBJECTIVE 22

Install the relay.

INTRODUCTION

View the instructional videotape *Compressed Natural Gas Installation: Connect the CNG System Wiring* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- Relay
- Soldering gun and rosin core solder
- Split-loom tubing
- Heat-shrink tubing or tape
- Power drill

PROCEDURE

CAUTION

Disconnect the battery ground cable before you do any wiring.

1. Make sure that the component is complete and is not damaged.
2. Mount the unit on the firewall.
3. Wire the injectors to the relay.
4. Wrap the connections with heat-shrink tubing or tape.
5. Enclose the wiring with split-loom tubing.
6. Review your work for compliance with accepted standards and other requirements.
7. Clean the work area and return equipment and materials to their proper storage.

JOB SHEET 8	INSTALL A CNG SYSTEM 4

OBJECTIVE 23

Install the fuel gauge and CNG/gasoline switch.

INTRODUCTION

View the instructional videotape *Compressed Natural Gas Installation: Connect the CNG System Wiring* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- Fuel gauge and CNG/gasoline switch kit
- Soldering gun and rosin core solder
- Split-loom tubing
- Heat-shrink tubing or tape
- Power drill

PROCEDURE

CAUTION

Disconnect the battery ground cable before you do any wiring.

1. Make sure that the components are complete and are not damaged.
2. Locate the components where they can be easily *seen* and *accessed* by the driver.
3. Connect the components according to the manufacturer's instructions.
4. Secure wiring out of the way of any moving parts.
5. Mount the components.

   CAUTION

   Be careful not to drill through any wiring.

6. Review your work for compliance with accepted standards and other requirements.
7. Clean the work area and return equipment and materials to their proper storage.

JOB SHEET 9	INSTALL A CNG SYSTEM 4

OBJECTIVE 24

Install the CNG carburetor.

INTRODUCTION

The job of installing the CNG carburetor involves assembling the carburetor, mounting and connecting the carburetor, and hooking up vacuum lines. You can install the CNG carburetor before *or* after connecting the CNG system wiring. However, it might be easier to complete the wiring without the carburetor in the way.

View the instructional videotape *Compressed Natural Gas Installation: Install the CNG Carburetor* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- CNG carburetor kit
- Silicone sealant
- Vacuum hoses
- Vapor hose
- Soldering gun and rosin core solder
- Plastic tie straps
- Adel clamps
- Heat-shrink tubing or tape
- Split-loom tubing

PROCEDURE

ASSEMBLING THE CNG CARBURETOR

1. Attach the lift solenoid to the CNG carburetor.

2. Seal the port in the carburetor with silicone sealant.

3. Assemble the carburetor according to the manufacturer's instructions.

INSTALLING THE CNG CARBURETOR

1. Secure the CNG carburetor on the throttle body or gasoline carburetor where it will not interfere with other working parts.

   NOTE: Be sure that the carburetor has a gasket on top and will not interfere with other working parts, such as the throttle linkage. On some vehicles, OEM equipment, such as the air cleaner, will be reused.

2. Crimp and splice the ground lug.

3. Solder the connection with rosin core solder.

4. Wrap connections with heat-shrink tubing or tape.

5. Attach the engine ground wire to an engine ground.

6. Secure the carburetor wiring with plastic tie straps.

   NOTE: This will help prevent the wires from becoming tangled and creating a possible hazard.

7. Connect the lift solenoid on the CNG carburetor assembly.

   NOTE: Tape the lift solenoid wiring where needed.

8. Enclose the wiring with split-loom tubing.

HOOKING UP VACUUM LINES

1. Attach a vacuum hose from the *top* of the carburetor to the *bottom* of the solenoid.

2. Attach a vacuum hose from the *bottom* of the carburetor to the *top* of the solenoid.

3. Attach a vacuum hose from the balance port to the second-stage regulator.

4. Secure the hoses with adel clamps, where needed.

5. Attach a hose from the manifold vacuum source to the lift solenoid.

   NOTE: Use a "T" to splice into the existing vacuum source.

6. Clamp a vapor hose in place from the second-stage regulator to the carburetor.

7. Install the PCV hose from the valve cover grommet to the top of the air filter.

8. Review your work for compliance with accepted standards and other requirements.

9. Clean the work area and return equipment and materials to their proper storage.

JOB SHEET 10	INSTALL A CNG SYSTEM 4

OBJECTIVE 25

Purge and fill the system.

INTRODUCTION

You should purge the system before filling it for the first time.

View the instructional videotape *Compressed Natural Gas Installation: Fill the CNG Fuel Tank* as often as necessary and observe any on-site demonstrations before attempting the procedure.

EQUIPMENT AND MATERIALS

- Liquid leak detector

PROCEDURE

CAUTION

Never purge the system near an open flame!

PURGING THE SYSTEM

1. Remove the cap over the fill valve.
2. Connect the fill station hose to the fill valve.
3. Open the valve on the fill station hose.
4. Fill the tank to no more than three hundred (300) pounds of pressure.
5. Close the shut-off valve at the regulator.
6. Disconnect the fill station hose.
7. Close the tank valve.
8. Remove the fitting and shake the line to release the pressure in the line.
9. Open the tank valve and purge the system.

CAUTION

On humid, cool days, use a fuel line as a "vent stack" to vent the system away from the vehicle. Allow the system to leak completely down.

10. Replace the fitting.

CHECKING FOR LEAKS

1. Squirt liquid leak detector on all fitting connections.
2. Look for bubbles at any connection, indicating a leak.
3. Tighten and recheck any fittings where a leak is present.
4. Replace any defective, stripped or cracked fittings.

CAUTION

Close the valve at the tank and bleed-off the pressure before you replace any fittings.

5. Fill the system after you have stopped any leaks.
6. Return the fill station hose to its proper position.
7. Review your work for compliance with accepted standards and other requirements.
8. Clean the work area and return equipment and materials to their proper storage.

PRACTICAL TEST 1	INSTALL A CNG SYSTEM 4

JOB SHEET 1

Mount the CNG fuel tank.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Determined a suitable location for the CNG fuel tank.	____	____
3. Prepared the brackets before mounting.	____	____
4. Properly mounted the bottom half of the brackets.	____	____
5. Followed the guidelines for safe lifting when lifting the tank.	____	____
6. Properly positioned the tank.	____	____
7. Properly completed mounting the tank.	____	____
8. Labeled the fuel tank in accordance with standards.	____	____
9. Cleaned work area and returned equipment and materials to their proper storage.	____	____

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the participant on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
Tank is mounted using proper components and materials.	4	3	2	1
Tank is mounted in accordance with accepted standards.	4	3	2	1
Tank and its fiberglass wrap is not damaged in any way.	4	3	2	1
Tank is properly labeled.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 2	INSTALL A CNG SYSTEM 4

JOB SHEET 2

Seal and vent a CNG fuel tank mounted within a closed compartment (such as the trunk of a car).

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Applied double-adhesive tape.	_____	_____
3. Checked the tightness of all fittings.	_____	_____
4. Completely enclosed the valve and all fittings.	_____	_____
5. Clamped the bag tightly where required.	_____	_____
6. Cleaned work area and returned equipment and materials to their proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator Note: Rate the participant on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
Connections are sealed and vented using proper components and materials.	4	3	2	1
Connections are sealed completely and tightly.	4	3	2	1
Connections are vented in accordance with accepted standards (and not into a wheel well).	4	3	2	1
Seal is clamped securely and where required.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 3	INSTALL A CNG SYSTEM 4

JOB SHEET 3

Install the CNG regulator.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Assembled the regulator.	_____	_____
3. Determined a suitable location for the CNG regulator.	_____	_____
4. Mounted the regulator.	_____	_____
5. Connected the regulator to heater hoses.	_____	_____
6. Routed and secured the new hoses.	_____	_____
7. Replaced the antifreeze/coolant.	_____	_____
8. Cleaned work area and returned equipment and materials to their proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator Note: Rate the participant on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
Regulator is properly assembled before mounting.	4	3	2	1
Regulator is mounted using proper components and materials.	4	3	2	1
Regulator is mounted with round side facing upward or to one side.	4	3	2	1
Regulator is level.	4	3	2	1
Regulator is properly connected to heater hoses.	4	3	2	1
Shut-off valve on regulator assembly is properly labeled.	4	3	2	1
Completed installation meets accepted standards and other requirements.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 4	INSTALL A CNG SYSTEM 4

JOB SHEET 4

Install the CNG fuel line.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Correctly approximated the necessary length of the fuel line.	____	____
3. Cut the steel properly and to the required length.	____	____
4. Made stress loops in the line where needed.	____	____
5. Made bends in the fuel line where necessary.	____	____
6. Connected the fuel line at the CNG fuel tank and at the regulator.	____	____
7. Secured the fuel line to the vehicle every 24 inches or less.	____	____
8. Cleaned work area and returned equipment and materials to their proper storage.	____	____

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the participant on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
Fuel line is of the required length.	4	3	2	1
Fuel line has stress loops where needed.	4	3	2	1
Fuel line is properly bent where necessary.	4	3	2	1
Fitting threads are properly sealed.	4	3	2	1
Fuel line is connected where required.	4	3	2	1
Connections are tight.	4	3	2	1
Fuel line is secured to the vehicle every 24 inches or less.	4	3	2	1
Completed installation meets accepted standards and other requirements.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 5	INSTALL A CNG SYSTEM	4

JOB SHEET 5

Install the computer signal modification device.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Sealed the unit twice (once before and once after mounting).	____	____
3. Mounted the unit in a suitable location.	____	____
4. Connected the unit to all required sensors and according to manufacturer's instructions.	____	____
5. Wrapped connections with heat-shrink tubing or tape.	____	____
6. Enclosed wiring with split-loom tubing.	____	____
7. Cleaned work area and returned equipment and materials to their proper storage.	____	____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator Note: Rate the participant on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
Unit is properly sealed.	4	3	2	1
Unit is safely located.	4	3	2	1
Unit is connected to all necessary sensors according to manufacturer's instructions.	4	3	2	1
Connections are properly soldered or plugged (depending on the type of connection).	4	3	2	1
Connections are wrapped with heat-shrink tubing or tape.	4	3	2	1
Wiring is enclosed with split-loom tubing.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 6	INSTALL A CNG SYSTEM 4

JOB SHEET 6

Install the dual curve ignition.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Sealed the unit twice (once before and once after mounting).	_____	_____
3. Mounted the unit in a suitable location.	_____	_____
4. Enclosed the wiring with split-loom tubing.	_____	_____
5. Connected the wiring according to manufacturer's instructions.	_____	_____
6. Clamped the wiring to the firewall.	_____	_____
7. Cleaned work area and returned equipment and materials to their proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator Note: Rate the participant on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
Unit is properly sealed.	4	3	2	1
Unit is safely located.	4	3	2	1
Unit is connected according to manufacturer's instructions.	4	3	2	1
Connections are properly soldered.	4	3	2	1
Connections are wrapped with heat-shrink tubing or tape.	4	3	2	1
Wiring is clamped on the fire-wall and enclosed with split-loom tubing.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 7	INSTALL A CNG SYSTEM 4

JOB SHEET 7

Install the relay.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly mounted the relay.	_____	_____
3. Wired the relay to injectors.	_____	_____
4. Wrapped connections with heat-shrink tubing or tape.	_____	_____
5. Enclosed wiring with split-loom tubing.	_____	_____
6. Cleaned work area and returned equipment and materials to their proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator Note: Rate the participant on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
Relay is properly mounted on the firewall.	4	3	2	1
Injectors are wired to the relay.	4	3	2	1
Connections are wrapped with heat-shrink tubing or tape.	4	3	2	1
Wiring is enclosed with split-loom tubing.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 8	INSTALL A CNG SYSTEM	4

JOB SHEET 8

Install the fuel gauge and CNG/gasoline switch.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly located the components.	_____	_____
3. Connected the components according to manufacturer's instructions.	_____	_____
4. Secured wiring out of the way of any moving parts.	_____	_____
5. Properly mounted the components.	_____	_____
6. Cleaned work area and returned equipment and materials to their proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
Components can be easily seen and accessed by the driver.	4	3	2	1
Components are connected according to manufacturer's instructions.	4	3	2	1
Wiring is safely routed away from moving parts.	4	3	2	1
Components are correctly and safely mounted.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; *limited additional training may be required.*
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 9	INSTALL A CNG SYSTEM 4

JOB SHEET 9

Install the CNG carburetor.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Assembled the CNG carburetor according to manufacturer's instructions.	____	____
3. Properly installed the CNG carburetor.	____	____
4. Properly hooked up vacuum lines.	____	____
5. Wrapped connections with heat-shrink tubing or tape.	____	____
6. Enclosed wiring with split-loom tubing.	____	____
7. Cleaned work area and returned equipment and materials to their proper storage.	____	____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator Note: Rate the participant on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
CNG carburetor is assembled according to manufacturer's instructions.	4	3	2	1
CNG carburetor is safely located away from other moving parts.	4	3	2	1
CNG carburetor is properly installed.	4	3	2	1
Connections are properly soldered.	4	3	2	1
Connections are wrapped with heat-shrink tubing or tape.	4	3	2	1
Wiring is enclosed with split-loom tubing.	4	3	2	1
Vacuum hoses are properly attached on the CNG carburetor.	4	3	2	1
The vapor hose is properly attached.	4	3	2	1
The PCV hose is properly attached.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

INSTALL A CNG SYSTEM

JOB SHEET 10

Purge and fill the system.

STUDENT'S NAME _____ DATE _____

EVALUATOR'S NAME _____ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the participant has satisfactorily achieved each step in this procedure. If the participant is unable to achieve this competency, have the participant review the materials and try again.

The participant	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly connected the fill station hose.	_____	_____
3. Filled the system to no more than 300 pounds of pressure.	_____	_____
4. Purged the system.	_____	_____
5. Checked for leaks.	_____	_____
6. Stopped any leaks.	_____	_____
7. Replaced any defective, stripped or cracked fittings.	_____	_____
8. Filled the system.	_____	_____
9. Cleaned work area and returned equipment and materials to their proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator Note: Rate the participant on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate participant mastery. (See performance evaluation key.) A participant who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria				
CNG fuel line is free of leaks.	4	3	2	1
CNG fuel line and fuel tank are purged of air and any debris.	4	3	2	1
Fittings are in good condition.	4	3	2	1
System is filled.	4	3	2	1
Fill station hose is returned to its proper position.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 -	Skilled — Can perform job with no additional training.
3 -	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 -	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 -	Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST	INSTALL A CNG SYSTEM 4

NAME _____ SCORE _____

OBJECTIVE 1

State the accepted standard for the installation of CNG fuel systems for vehicles.

_____

_____

OBJECTIVE 2

Identify selected standards for installing the CNG fuel tank.
Write the correct letter in each numbered blank.

_____1. Locate the fuel tank ___.

a. where it is accessible and clear of obstructions
b. ahead of the front axle
c. behind the rear bumper mounting face
d. anywhere on the vehicle, as long as the tank does not negatively affect the driving characteristics of the vehicle

_____2. Which of the following components of a CNG system must be located to be easily inspected and serviced?

a. The fuel tank
b. The container valve
c. The connections
d. The fuel tank, valve and connections

_____3. What is a standard for installing a manually-operated container valve on CNG fuel tanks?

a. On tanks mounted inside a closed compartment only
b. On tanks mounted outside a closed compartment only
c. On each tank
d. On every other tank in a properly-connected pair

OBJECTIVE 3

Explain the importance of sealing and venting a CNG fuel tank mounted within a closed compartment.

OBJECTIVE 4

Identify selected standards for sealing and venting CNG components mounted within a closed compartment. Write an "X" in the blank beside each standard.

_____1. Vent all pressure relief devices and pressure-carrying components installed within a closed compartment to the outside of the vehicle.

_____2. Vent all pressure relief devices and pressure-carrying components installed within a closed compartment into a wheel well.

_____3. Vent all pressure relief devices and pressure-carrying components installed within a closed compartment into another pressure relief device.

OBJECTIVE 5

Explain how the regulators operate in a CNG system.

OBJECTIVE 6

Identify selected standards for installing regulators. Write an "X" in the blank beside each standard.

_____1. Install regulators so that they will not freeze when CNG passes through them.

_____2. Install regulators so that their weight is supported by the CNG fuel line.

_____3. Install regulators so that their weight is not placed on the CNG fuel line.

_____4. Install the regulator with the round side facing forward.

_____5. Protect pressure gauges from damage caused by vibration or unsecured objects.

OBJECTIVE 7

State three safety rules to follow while installing the CNG regulator.

1. _____

_____

2. _____

_____

3. _____

_____

OBJECTIVE 8

State the specifications for high-pressure fittings and tubing used in the CNG fuel line.

For stainless steel fittings:

_____

For stainless steel tubing:

_____

OBJECTIVE 9 **List possible locations for stress loops in the fuel line.**

1. _____

2. _____

3. _____

4. _____

OBJECTIVE 10 **Identify selected standards for installing the CNG fuel line and fittings.** Write an "X" in the blank beside each standard.

_____1. Make sure that all fuel lines and fittings are clear of obstructions.

_____2. Use aluminum or copper fuel lines or fittings between the CNG fuel tank and the first-stage regulator.

_____3. Protect the fuel line with grommets as needed to prevent abrasion wherever the line passes through a panel.

_____4. Support the fuel line every 24 inches or less.

_____5. Support the fuel line every 48 inches or less.

_____6. Locate all connections where they are accessible.

OBJECTIVE 11 **State the major steps in connecting the CNG system wiring.** Write the steps in any order.

1. _____

2. _____

3. _____

4. _____

OBJECTIVE 12

Explain the function of major electronics add-ons in a CNG system.

Computer signal modification device — _____

_____

_____

_____

_____

_____

Dual curve ignition — _____

_____

_____

_____

_____

Relay — _____

_____

_____

_____

Fuel gauge — _____

_____

_____

_____

CNG/Gasoline switch — _____

_____

_____

_____

OBJECTIVE 13 **State general safety rules to follow while connecting the CNG system wiring.**

1. _____

_____

2. _____

_____

3. _____

_____

4. _____

_____

OBJECTIVE 14 **Identify selected standards for testing the CNG system.** Write an "X" in the blank beside each standard.

_____1. Check every connection for leaks, using commercially-available liquid leak detector or a leak detector instrument, after the CNG system is installed and after some pressure is added.

_____2. Be sure that you have adequate ventilation when leak testing with CNG.

_____3. If the CNG fuel tank is damaged in an accident or fire, replace the fuel tank or remove it, inspect it, and retest it as required at the next scheduled date for inspection.

_____4. If any part of the CNG system is damaged in an accident or fire, retest the system before returning the vehicle to service.

OBJECTIVE 15 **Identify the order of basic steps for testing and adjusting the system.** Arrange the steps in order by writing the correct number 1-6 in each blank.

_____ Start the vehicle on CNG.

_____ Stop the engine, disconnect the dual curve ignition, start the vehicle on gasoline, advance the timing, then recheck the timing.

_____ Adjust the pressures on the regulators. Adjust the pressure on the first-stage regulator (with its cap removed) until it reads in the range of 40-100 pounds (depending on the brand used).

_____ Adjust the pressure on the second-stage regulator (with its cap removed) until it reads in the range of 3-5 ounces or 2-7 inches of water column.

_____ Switch to CNG, then set the idle speeds on CNG and adjust the load screws.

_____ Reconnect the dual curve.

_____ Test drive the vehicle to determine that it is operating properly. Use a dynamometer, if available, for faster and more precise adjustments.

_____ Apply the CNG label on the right rear of the vehicle, above the bumper.

NOTICE The following objectives are not a part of the Written Test.

OBJECTIVE 16 **Mount the CNG fuel tank.** RATING _____

OBJECTIVE 17 **Seal and vent a CNG fuel tank mounted within a closed compartment (such as the trunk of a car).** RATING _____

OBJECTIVE 18 **Install the CNG regulator.** RATING _____

OBJECTIVE 19 **Install the CNG fuel line.** RATING _____

OBJECTIVE 20 **Install the computer signal modification device.** RATING _____

OBJECTIVE 21	**Install the dual curve ignition.**	RATING _____
OBJECTIVE 22	**Install the relay.**	RATING _____
OBJECTIVE 23	**Install the fuel gauge and CNG/gasoline switch.**	RATING _____
OBJECTIVE 24	**Install the CNG carburetor.**	RATING _____
OBJECTIVE 25	**Purge and fill the system.**	RATING _____

WRITTEN TEST ANSWERS	INSTALL A CNG SYSTEM 4
OBJECTIVE 1	*National Fire Protection Association (NFPA) Pamphlet No. 52.*
OBJECTIVE 2	1. a 2. d 3. c
OBJECTIVE 3	Although CNG is not toxic, it can cause asphyxiation if it displaces the normal concentration of oxygen in air in an area that does not have adequate ventilation. If you are mounting the CNG fuel tank(s) in the trunk of a car, then enclose the shut-off valve and all connections in an approved plastic bag. This bag will help prevent any gas leaks from entering the car. Instead, the gas will be contained in the bag and will be released into the outside air through the same hole made in the floorboard for the CNG fuel line.
OBJECTIVE 4	1
OBJECTIVE 5	When the vehicle is started, the CNG flows through a stainless steel high-pressure fuel line along the underside of the vehicle from the CNG fuel tank to a regulator. This regulator includes a first-stage or high-pressure regulator and a second-stage or low-pressure regulator. The first-stage regulator brings the CNG down from as much as 3,000 pounds of pressure to about 40-100 pounds (depending on the brand used); the second-stage regulator brings the CNG down even more, to about 3-5 *ounces* of pressure.
OBJECTIVE 6	1, 3, 5
OBJECTIVE 7	In any order: • Mount the regulator away from a heat source. • Be sure that a pressure-sensitive and temperature-sensitive pressure relief device is installed at the CNG fuel tank. • Use high-pressure fittings and tubing that meet the following specifications in all fuel lines: stainless steel fittings, 10,000 psi tested; and stainless steel tubing, 6,000 psi tested.

OBJECTIVE 8

For stainless steel fittings: 10,000 psi tested
For stainless steel tubing: 6,000 psi tested

OBJECTIVE 9

In any order:

- Before connections at the regulator
- At the shut-off valve at the fuel tank
- Midway on long runs of tubing
- In the section of the fuel line connecting the tanks

OBJECTIVE 10

1, 3, 4, 6

OBJECTIVE 11

In any order:

1. Install a computer signal modification device.
2. Install a dual curve ignition system.
3. Install a relay.
4. Install a fuel gauge and CNG/gasoline switch.

OBJECTIVE 12

Computer signal modification device — This unit provides information to the vehicle's computer, so that the computer responds properly when the vehicle is operating on CNG instead of gasoline. Specifically, this unit prevents false malfunction codes from the oxygen sensor, prevents false warning codes relating to exhaust gas recirculation (EGR), prevents false warning codes relating to the "knock sensor," and prevents the computer from retarding the spark timing on CNG.

Dual curve ignition — This unit allows the engine ignition to advance the timing fifteen (15) degrees when running on CNG, and returns it to OEM basic timing when running on gasoline.

Relay — This unit facilitates the switch to or from CNG by "carrying the load."

Fuel gauge — This unit shows the amount of CNG in the fuel tank, from "full" to "empty." It may be a separate LED unit for CNG only or a dual display for gasoline and CNG.

CNG/Gasoline switch — This unit allows the driver to switch from gasoline to CNG, and back again, without stopping the vehicle.

OBJECTIVE 13	• Always install the computer signal modification device and the dual curve ignition away from heat sources. • Solder all wire connections with rosin core solder. • Wrap connections with heat-shrink tubing or tape. • Relocate the ignition coil at least six inches away from the distributor.
OBJECTIVE 14	1, 2, 4
OBJECTIVE 15	2, 4, 1, 3, 6, 5, 8, 7